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Scientific Practices For Student-Centered Inquiry: The Impact Of A Focus On Student Proficiency In Data Analysis And Scientific Argumentation On Inquirybased Practices In A First-Grade Classroom

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SCIENTIFIC PRACTICES FOR STUDENT-CENTERED INQUIRY: THE IMPACT OF A FOCUS ON STUDENT PROFICIENCY IN DATA ANALYSIS AND SCIENTIFIC ARGUMENTATION ON INQUIRY-BASED PRACTICES IN A FIRST-GRADE CLASSROOM

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Dedication

In dedication to the many people who made this work possible. Thank you to my first-grade students, who inspire me each day with their brilliance. I am grateful to the Professional Learning Community of first-grade teachers who challenge and support me to grow professionally through continuous refinement of my practice. Above all, I dedicate this work to my family. I could never repay my amazing parents who did anything to support me through this process, from entertaining my children to contributing to the cost of my program. My patient children, Ellie Kate and Ethan, sacrificed time spent with mommy as I completed this work. Despite the sacrifices, they helped me through this process with scavenger hunts, special notes of encouragement, and unwavering forgiveness. Last, but not least, thank you to my husband Quentin, who lifted me up and carried me through the entire process with unconditional love and support. This dissertation belongs to all of these people because it was not possible without them.

Abstract

Previous to this study, teaching and learning practices in the first-grade classroom of study were primarily teacher and content driven and did not reflect the student-driven inquiry process. The identified problem of practice for this action research study was the first-grade students in the teacher-researcher classroom did not demonstrate inquiry or scientific literacy through content-centered teaching practices. The research plan presented addressed the use of scientific practices as they related to inquiry-based teaching and learning. An action research methodology was used to explore the instructional tools that increased student proficiency in two specific scientific practices: analyzing and interpreting data and generating arguments from evidence. The impact of a focus on scientific practice on the inquiry-based teaching and learning practices within a first-grade International Baccalaureate Primary Years Programme School were also investigated. This study was conducted over a six-week period in Spring 2018.

Table of Contents

List of Tables

Chapter 1:

Introduction

Overview of Dissertation in Practice

This Dissertation in Practice (DP) described action research in which a teacher-researcher inquired and reflected upon the use of inquiry and scientific practices within her classroom. It was a teacher's attempt to understand the multiple ways I, as the teacher-researcher, and my students experienced the teaching and learning process. Cochran-Smith and Lytle (2009) stated the educational accountability era narrowed the school curriculum and reduced the role of both teachers and students. Further, they argued that the authentic experts on how to best serve students were teachers who systematically inquired about and reflected on their instructional practices. The case study of this DP explored the varied insights and experiences of a teacher and her students as they interacted together in the learning environment.

The global innovation-driven economy of the 21st century emphasized the benefits of scientific and inquiry literacy. According to Darling-Hammond (2008), 95% of labor needed in the 20th century required employees to follow necessary procedures to complete low-skill manual labor. In the 21st century, this category of labor only made up approximately ten percent of jobs within the United States economy (Darling-Hammond, 2008). Tony Wagner (2015) argued that occupations in the innovation-driven economy of the 21st-century required skills such as inquiry, creativity, critical thinking, communication, and collaboration. Lacey & Wright (2009) predicted science-related occupations would increase at a faster rate than that of all other fields. Educators must employ teaching and learning practices that prepare students to meet the professional and cultural needs of the 21st century.

Persistent gender and racial achievement gaps indicated employment barriers for specific populations in the global innovation-driven economy. Wagner (2015) described multiple studies that found minorities and women were significantly underrepresented in science-related fields (Beede, Julian, Langdon, McKittrick, Kahn, & Doms, 2011; Hrabowski, 2011; Neuhauser, 2015). This imbalance in science achievement and labor participation among social groups demanded educators to reevaluate teaching and learning practices. Barron and Darling-Hammond (2008) revealed numerous studies that demonstrated significantly higher science achievement for students who participated in inquiry-based learning in the early grades, regardless of race, gender or previous performance.

The development of science skills in the first grade significantly impacted future science achievement, particularly for female and nonwhite students. Curran and Kellogg (2016) found evidence from multiple studies that indicated the racial and gender achievement gaps in science widened considerably between kindergarten and third grade. These disparities, according to Curran and Kellogg, remained consistent from third grade into high school. Research discovered early science achievement was highly predictive of future science achievement (Morgan, Farkas, Hillemeier, & Maczuga, 2016). Increasing scientific literacy through an inquiry-based approach in the early grades was critical to narrowing future gender and racial achievement gaps.

Background

Learning through inquiry played a central role in the International Baccalaureate (IB) standards and principles. The IB program's reference book, *Making the PYP Happen—A curriculum framework for international primary education* asserted theorists, research, and experience suggested students learn best when actively engaged in their learning within structured, purposeful inquiry (International Baccalaureate Organization [IBO], 2009). The International Baccalaureate Organization (2009) argued an inquiry-based concept-driven curriculum allowed the learner to construct meaning rather than passively absorb it.

The study site was authorized as an IB PYP school in 2005 and began using the IB PYP curriculum framework to guide instruction. In 2013 the study site completed a self-study and IB evaluation to assess school-wide alignment with the principles and standards of the IB PYP. Specific areas of practice that did not align with the guidelines of the IB PYP were identified during the self-study and the IB PYP evaluation. The study site created a five-year action plan to address these areas and other recommendations of the IB PYP evaluators. The IB PYP five-year action plan established a priority for Professional Learning Communities to design concept-driven units of inquiry that address a central transdisciplinary theme based on the IB PYP curriculum framework.

Grade-level Professional Learning Communities (PLC) were redesigned to meet once a week to reflect on student learning within the unit of inquiry as part of the five-year action plan. A PLC comprised of seven first-grade teachers articulated a shared commitment to purposeful inquiry that supported student efforts to construct meaning within a concept-based unit of inquiry. The first-grade teachers developed six units of inquiry-based explorations and investigations to build connections and understandings within an overarching concept.

At the culmination of an inquiry unit addressing an overarching concept, the teacher-researcher reflected with her PLC that the initial momentum in using inquiry-based instructional practices diminished as the unit progressed. Teachers within the PLC relied on a more content-driven approach to teaching and learning than the student-centered inquiry-based approach of the IB PYP. An informal survey found teachers used traditional teaching practices on average more than seventy percent of the instructional time. Students were not able to demonstrate inquiry literacy within planned inquiry-based projects. In response to student inability to participate in the inquiry process, my colleagues and I relied on a traditional content-based approach to teaching scientific concepts.

Bell, Smetana and Binns (2005) stated the levels of inquiry instruction were on a continuum ranging from full student ownership of the inquiry experience to minimal student ownership within a structured learning experience. Rezba, Auldridge, and Rhea (1999) described the levels along this continuum as confirmation, structured, guided, and open inquiry. Melville, Bartley and Fazio assigned the differentiation between these levels to factors "such as the teacher-supplied structure, the existence of a solution to the question, the complexity of the activity, or the amount of information that is provided to the student" (Melville et al., 2012, p. 1258). Research suggested teachers struggled to help students engage in inquiry practices because of confusion over the meaning of inquiry and the appropriate levels of teacher guidance (Ireland, Watters, Brownlee, & Lupton, 2014).

Clearly defining the primary role of the teacher in the use of inquiry-based practices was essential to understanding the discrepancy between intention and practice my PLC and I observed in our classrooms. The role of the teacher in the current level of practices in my classroom aligned with the definition of highly structured inquiry on the continuums described by Rezba, Auldridge, and Rhea (1999) and Staver and Bay (1987). The teacher provided the problem and materials to guide students to a specific outcome in structured inquiry (Staver & Bay, 1987). Staver and Bay (1987) defined the role of the teacher in guided inquiry to be a facilitator who provided students with an investigation or problem, but allowed the students to solve the problem, challenge their understanding of concepts and draw their own conclusions. I clarified the intended level of inquiry-based practices for my classroom to align with the definition of guided inquiry based on these continuums, which established a priority for the teacher to act as facilitator.

Once the level of inquiry was defined, the next step was to establish clarity of proficient practices within the parameters of guided inquiry. Over the past few years standards and practices were developed and published to address the need for clarification and definition in the field of inquiry. The National Research Council presented Science and Engineering Practices in the *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* in 2012. In 2014, South Carolina established Science and Engineering Practices as skills and abilities to be integrated with Science content standards. Marshall, Horton, and White (2009) designed the EQUIP protocol and rubric to provide a clear definition of quality inquiry-based practices for teachers and students on a continuum from low to high quality. These tools were used to establish distinct, observable behaviors and practices on a continuum from undeveloped to exemplary guided inquiry-based instruction and learning within my classroom.

Problem of Practice Statement

The problem of practice for this study developed out of a personal observation of an increasing discrepancy between the commitment to use student-led inquiry teaching practices and the actual implementation of those practices within the inquiry unit of an overarching scientific concept. An informal survey within my Professional Learning Community (PLC) further strengthened my observations. I was not the only teacher observing this discrepancy between intention and practice. A variety of research studies cited ambiguity as a primary obstacle to teacher proficiency in inquiry-based instruction (Crawford, 2000; Furtak, Seidel, Iverson, & Briggs, 2012; Ireland, Watters, Brownlee, & Lupton, 2014; Keys & Bryan, 2001).

The Science and Engineering Practices in the *Framework for K-12 Science Education* created by the National Research Council (2012), the South Carolina Science and Engineering Practices (2014), and the EQUIP protocol developed by Marshall, Horton, and White (2009) provided a clear definition of quality inquiry-based practices for teachers and students. Using the EQUIP continuum as a measurement tool, the current practices in my classroom rarely maintained a proficient or exemplary level throughout the entire inquiry process. Students were able to ask questions and carry out investigations at a proficient or exemplary level, but they were not able to construct explanations and arguments using evidence from their inquiry at that same level of proficiency. The inquiry process was disrupted as a result of this change in student proficiency level between science practices. This disruption shifted the instruction from student-centered to content-centered, which was a significant problem in my practice. The problem of practice of this DP was my students were not demonstrating proficiency in scientific practice throughout the inquiry process.

Purpose Statement

The primary purpose of this action research study was to explore the factors of instruction and learning that served as barriers or supports to proficient or exemplary implementation of inquiry-based practices within my classroom. I designed this study to explore how my students and I gained proficiency in scientific practices, and how that process impacted the quality of inquiry-based learning. The secondary purpose was to design an Action Plan to sustain a student-centered inquiry approach that would increase students' scholarly achievement in science in my classroom.

Research Question 1: How do a teacher and her students develop student proficiency in generating an argument from evidence and analyzing and interpreting data in a first-grade classroom?

Research Question 2: How does a focus on specific science practices maintain the level of guided scientific inquiry in a 1st grade classroom?

Theoretical Base

The student-centered focus of inquiry-based learning (IBL) transformed the assumption that student achievement, as reflected by state and district standardized tests, solely relied on student ability to absorb content. Through the IBL approach students actively constructed meaning and gained information by questioning, exploring, discussing, and testing (Prince & Felder, 2006). Inquiry-based learning (IBL) was rooted in the constructivist cognitive theory promoted by John Dewey (1938) who proposed students constructed meaning and knowledge rather than passively absorbing content. A fundamental component of the constructive learning theory was the learner. The constructivist theory asserted knowing was a process unique to the experiences and background to the learner (Ultanir, 2012; Prince & Felder, 2006). Constructivism required the student to actively create meaningful associations between prior knowledge and interactions with the environment. Learners constructed knowledge and understanding through a cognitive process of examination, critical thinking, and reflection (Barrell, 2016; Perkins, 1992).

The social constructivist model assumed learners organized and restructured information through social interactions (Vygotsky, 1978). Vygotsky's social constructivist theory stressed the interdependence of individual and social processes of creating meaning. The teacher, the student, and the environment were always active in the learning process (Davydov, 1995). Richardson (1997) stated that social interaction was a necessary element of learning because meaning could only be constructed through language in a social context. The learner developed and internalized an understanding of concepts or content through experiences and interactions with peers and experts in a social context (Crawford, 2012).

Overview of Study Design

The methodology and design of this study was informed by the theoretical assumptions of social constructivism. The social constructivist approach to research assumed participants created multiple meanings and perspectives as they interacted. The need to understand these varied perspectives within my classroom guided the design of this study. The interpretive paradigm was a research philosophy that engaged teachers in reflective practice that brought a deeper understanding of the forces that impacted the pedagogies, curriculum, and systems within their classrooms (Taylor & Medina, 2013). The action research process aligned with interpretive research (deVilliars, 2005). Action research was an appropriate method to address these research questions because it enabled me, as the teacher-researcher, to create change within my specific environment (Stringer, 2007). The stages of this action research study outlined in Chapter 3 included planning, taking action, developing an action plan, and reflecting.

Qualitative research methods best aligned with the primary purpose of this DP. The purpose of the research was exploratory in nature, and therefore the variables were largely unknown. The design of the study provided the flexibility to adjust as variables arose. Creswell (2014) described the qualitative approach to research as an emergent design in which researchers tried to create a holistic account of the problem under study. Qualitative researchers collected multiple sources of data to interpret patterns and themes and identify the multiple perspectives and facets of a process or phenomenon (Creswell, 2014). Quantitative methods required researchers to identify variables to be manipulated and measured states (Creswell, 2014). Qualitative methods would allow me to explore the unique viewpoints and reflections of the students in my classroom without measuring or manipulating predetermined variables. Data collected through quantitative methods was primarily numerically based, while qualitative methods relied on descriptive-based information. Data collected through qualitative methods provided a deeper understanding of the factors that acted as barriers or supports in the inquiry process than numerical data can.

The case study design was the appropriate application of qualitative approach for this study because it involved the exploration of my teaching practice within the specific boundaries of inquiry-driven teaching and learning in my first-grade classroom. The primary characteristic of the case study design was a focus on the unit or phenomenon rather than the outcome of the research (Merriam, 2009). The problem of practice and research questions were centered around the process of inquiry-based practices, not the outcomes of inquiry-based practices. A case study design aligned with the intentions of this study.

Multiple forms of data were collected to obtain the most detailed picture of what was occurring in the classroom (Dana & Yendol-Hoppey, 2014). The use of a variety of sources allowed the researcher to identify perspectives and understandings that coincided through the process of triangulation (Yin, 2014). Qualitative data collected from lesson observations, performance assessments, lesson transcripts, and teacher-researcher recorded field notes were coded, organized, and interpreted using non-statistical inductive and descriptive analysis (Riazi, 2016). Data was also collected through student artifacts in a student-created portfolio. These documents provided contextual information that was observable to confirm data from other sources (Stake, 1995). According to Brown (2008), the thinking and theorizing about the data that occurred through this type of analysis provided an interpretive narrative of the heart of the case.

Limitations and Considerations

This study was designed to provide descriptive evidence of how a particular population of students and their teacher experienced instructional structures focused on the development of student proficiency in generating an argument from evidence. The data collected and analyzed was unique to my first-grade class and therefore was not able to support generalizations beyond the study population. The study was conducted within a unit of inquiry into natural resources. These limitations reduced the ability to make generalizations regarding the range of student inquiry or scientific literacy that could be developed as a result of instruction focused on generating high quality arguments from evidence. Educators could make connections with the findings of this study and apply those connections and discoveries to their populations.

As the teacher-researcher, I considered the possibility of personal interest in the success of an instruction to development student proficiency in generating an argument from evidence to increase the use of inquiry-based practices with my classroom. An additional consideration was my motivation to promote social change by increasing access and opportunities for historically marginalized groups. In response to these concerns, I observed and interpreted data with an unbiased perspective. I also consulted colleagues within my PLC to interpret data and analyze results to receive varying viewpoints.

Significance of Study

The research and literature presented in this chapter established the priority for increased scientific literacy through an inquiry-based approach. Educators realized the necessity to service the historically marginalized groups of elementary students in the area of science. The development of scientific inquiry was even more critical in the early grades such as first-grade, as Curran and Kellogg (2016) demonstrated through their findings. Gaps in the literature regarding science education and instructional strategies addressing the persistent gender and racial achievement gaps created a priority for this study. Despite the limitations in generalizing across populations, this action research study provided insight into alternative instructional strategies for fellow educators to explore.

An examination of social justice concepts demonstrated how groups were socialized to internalize subordination and domination. Adams (2013) stated social identities have been socially constructed within particular historical situations to justify and continue a cycle of inequality and oppression. According to Blackmon's (2008) account, the establishment of racial differences was increasingly beneficial to the development of the southern society throughout the years between the 1650s and those following the Civil War. The use of black labor was significant to the industrial and economic development of the south. As a result, the social construction of race in the south included the general idea that black labor was something to be consumed (Blackmon, 2008). Members of American society were socialized to accept the cultural perspective of the socially dominant group, further perpetuating a system of oppression and marginalization.

Hardiman, Jackson and Griffin (2013) found oppression persisted through generations at the institutional level though policies, practices, and social norms. Harro (2013) contended misguided assumptions and socially constructed identities allowed the cycle of an unjust social system to continue. An example of a mistaken assumption was one that believed the social group primarily capable of science achievement and future participation in scientific fields was White males. Research found stereotypes and the responses they elicited at the individual, institutional, and cultural level impacted student achievement (Aronson, 2004; Massey, Charles, Lundy, Fischer, 2003). Hill, Corbett, and Rose (2010) found girls across socioeconomic groups internalized messages from cultural norms and stereotypes that affected interest, achievement, and confidence in science-related skills.

The traditional science teaching practices of the 20th century generated consistent inequities in science achievement among gender and racial groups according to the literature presented in this chapter. The institution of public education had a responsibility to address these achievement gaps to ensure equal access to occupations in the global economy of the 21st century. This action research study provided an opportunity for the teacher-researcher to challenge gender and racial stereotypes by exploring student-centered instructional practices to increase inquiry and scientific literacy of students across social groups.

A considerable amount of research has been conducted on the benefits of inquiry-based practices. Conversely, an insignificant presence of literature exists on specific instructional strategies that increased inquiry literacy and scientific practice among early childhood students. This action research study investigated the particular instructional practices that increased student proficiency in scientific practices. The results of this study gave insight to the teacher-researcher and her colleagues as they continuously adjusted instructional and learning practices to meet student needs. The study was consequently designed to increase inquiry-based scientific practices for first-grade students. The results of this study added to the current literature on scientific instructional practices and methods that enhance science achievement for students of all socioeconomic, gender, and racial groups.

Dissertation in Practice Overview

Chapter 1 of this Dissertation in Practice (DP) introduces the purpose and problem of practice for the action research study investigating teacher-researcher and teacher-participant practices. The action research study research question, related literature, and research design will be presented. Chapter 2 of the DP is a more comprehensive review of related literature on inquiry- and science-based practices and their impact on student learning. Chapter 3 describes the methodology of the action research study. Findings, discoveries, analyses, and reflections will be discussed in Chapter 4. Chapter 5 summarizes the major points and conclusions of the DP and described suggestions for future action.

Glossary of Terms

It is valuable to know the meaning of the terms consistently used throughout this DP. The following two definitions are key terms discussed in reference to the problem of practice of this study.

Content: Content refers to the body of knowledge and information within a given subject area such as mathematics or science (Glossary of Education Reform).

Cognitive: Relating to, of, or involving mental activities such as thinking understanding, learning, and remembering (Merriam-Webster, 2013).

Inquiry-Based Instruction: A teaching method in which the teacher creates an environment where students are encouraged to learn for themselves as they engage in open-ended, student centered, hands-on activities (Colburn, 2006).

Inquiry-Based Learning: A student-centered, active learning approach in which the learner answers questions through investigation (Colburn, 2006; Savery, 2006).

Inquiry Literacy: One's competence in the inquiry process, which includes asking purposeful questions, seeking relevant evidence, understanding there are multiple ways to solve problems, and communicating effectively with others. (Walker & Shore, 2015).

Scaffolding: Support is given to assist learners in the acquisition of skills that is slowly released as students become more independent in demonstrating or understanding the skill (Dennon & Burner, 2007).

Scientific Practice: Practices encompass the skills and knowledge necessary to engage in scientific investigation. (National Research Council, 2012).

Chapter 2:

Literature Review

Introduction

The study site was a public school guided by state-mandated standards when it was authorized as an International Baccalaureate Primary Years Programme (IB PYP) school in 2005. Once authorized as an IB PYP school, it was expected to adhere to the non-negotiable IB PYP *Programme Standards and Practices* (International Baccalaureate Organization [IBO], 2014). A required teaching and learning standard of the IB PYP, Standard C3, was "Teaching and learning engages students as inquirers and thinkers. The school ensures that inquiry is used across the curriculum and by all teachers" (IBO, 2014). The IB PYP curriculum framework promoted an inquiry-based and student-centered approach to learning.

Teachers across grade levels at the study site were committed to merging state-mandated curriculum standards with required IB PYP standards and practices. Teachers collaborated with other IB PYP schools on teaching practices that engage students as inquirers and thinkers at yearly IB PYP conferences. First-grade teachers created six units of inquiry, each defined by one of the six transdisciplinary theme of the IB PYP: *Who we are, Where we are in place and time, How we express ourselves, How the world works, How we organize ourselves,* and *Sharing the planet.* Each unit explored a concept-driven central idea of the transdisciplinary theme. All state-mandated science, math, language arts, and reading standards were integrated across the six units of inquiry.

The teacher researcher of this study implemented the units of inquiry in a first-grade classroom. An inquiry cycle was used as a guide to engage students as inquirers and thinkers. My colleagues and I reflected on teaching and learning practices at the culmination of each unit. At the end of a unit of inquiry the teacher researcher indicated that students demonstrated natural curiosity about the patterns of the sun and moon and enthusiastically participated in related investigations. Despite the presence of student questioning and the use of relevant investigations, the teacher researcher reflected that teaching and learning practices within the unit were predominantly content and teacher-centered. The teacher-centered investigations were driven by the content as opposed to the inquiry process.

The following literature review explored the theoretical framework of inquiry-based learning (IBL) and the related research of IBL as a classroom practice. The research highlighted the potential benefits and difficulties teachers may encounter when implementing IBL practices. The National Academy of Science (2012) and the South Carolina Science and Engineering Practices (2014) provided clearly defined scientific practices to address each stage in the inquiry process. Literature supporting the connection between scientific practices and inquiry-based instruction was reviewed. The research, models, and concepts presented in the literature provided the instructional framework to address the problem of practice. The methods implemented in this study were based on the framework developed out of this literature review.

Purpose Statement

The primary focus of this Dissertation in Practice (DP) derived from my efforts to transform the culture of a classroom from predominantly content-centered to student centered. The purpose of the study was to increase authentic and purposeful inquiry in a first-grade classroom by increasing proficiency in scientific practices, while simultaneously addressing state-mandated science standards within a concept-based unit on natural resources. The particular force investigated in the study is the utilization of instructional scaffolds in the development of scientific practices to guide students and increase teacher and student competence in inquiry-based learning. The secondary purpose is to design an Action Plan to sustain a student-centered inquiry approach focused on scientific practices that will increase students' scholarly achievement in science.

Problem of Practice

The identified problem of practice for the present action research study was teaching and learning practices in my first-grade classroom were primarily teacher and content driven and did not reflect the student-driven inquiry process required by IB PYP standards. Students were able to inquire about scientific concepts by asking questions and explore those concepts competently, but they were not able to analyze and interpret data to generate a scientific argument.

The following questions were addressed in reference to the problem of practice:

1. What is the impact of instruction focused on the development of student proficiency in generating an argument from evidence in a first-grade classroom?

2. How does a focus on specific science practices maintain a proficient level of scientific inquiry in a first-grade classroom?

Importance of the Literature Review

The literature review was relevant to the research questions and investigation of the problem of practice in three primary ways. First, the literature regarding the historical context of curriculum presented the main source of conflict leading to the problem of practice. The literature highlighted the long and extensive histories of the different learning theories and curriculum ideologies guiding the curriculum in my first-grade classroom.

Secondly, the literature review established the magnitude of the teacher acting as both teacher and researcher in addressing the problem of practice. The literature provided the key elements of teacher research that shaped and reshaped the research questions and methods of addressing the problem of practice. The research related to scientific practices, thinking routines, cognitive apprenticeship, and other scaffolds exposed through the literature reviewed revealed an underlying deficiency within the teaching and learning practices contributing to the problem of practice. This led to refinement of both the problem of practice and the research question addressed in this DP.

Finally, the literature review provided the theoretical support for inquiry-based and scientific practices in a first-grade classroom. Significant research demonstrated the benefits of a curriculum guided by the constructivist learning theory in which the student is an active and essential participant in the learning process. Literature also demonstrated benefits of the transmission learning theory in which direct instruction primarily guides the curriculum. The literature, however, did not show an increase in critical or creative thinking, student-led questioning, or student motivation as the benefits of direct instruction.

This chapter explored teaching and learning approaches to developing scientifically proficient individuals. The research provided a continuum of teacher structure within inquiry-based learning models. Educational researchers presented a variety of inquiry learning cycles to guide the investigative process for teachers and students. A relationship between these inquiry cycles and scientific practices was established through the following literature review. Classroom research and investigations of inquiry or scientific practices provided significant evidence that discourse and instructional factors impact student ability to engage in inquiry and scientific practices, but little evidence of effective implementation of specific instructional and discourse scaffolds to increase student proficiency was found. This study concentrated on specific areas absent in the research through the action research methodology.

Action Research Methodology

The problem of practice presented in this DP originated in the negotiation of curriculum within the classroom of the teacher researcher. Hill, Stremmel, and Fu (2005) defined the negotiation of curriculum within a classroom as a system of collaboration between the students and the teacher. The action research process as was an appropriate method to address this research question because it enabled me to create change with the particular environment and students of which the negotiated curriculum related to and affected (Stringer, 2007). The stages of this action research study outlined in Chapter Three included planning, taking action, developing an action plan, and reflecting.

Multiple forms of data were collected to obtain the most detailed picture of what was occurring in the classroom (Dana & Yendol-Hoppey, 2014). Data was collected through performance assessments, lesson observations, teacher-researcher field notes, and student artifacts in a student-created portfolio. Qualitative data collected from transcribed lessons, PLC observation notes and ratings, and teacher-researcher recorded field notes were coded, organized, and interpreted using non-statistical inductive and descriptive analysis (Riazi, 2016).

Theoretical Base

Many terms were used to describe inquiry-based learning. Most consistently inquiry was defined in the literature as a pedagogical approach in which students posed and answered questions by engaging in investigation and research (Bybee, Taylor, Gardner, van Scotter, Carlson, & Westbrook, 2006; National Research Council, 2000; Pedaste, Maeots, Leijen, & Sarapuu, 2012; White & Frederiksen, 1998). In a review of the literature Spronken-Smith, Bullard, Ray, Robberts, and Keiffer (2008) found common attributes across research and definitions of IBL. Spronken-Smith et al. (2008) listed attributes essential to IBL throughout the literature were (a) the student is an active learner, (b) the approach to learning is question-driven, and (c) the teacher acts as a facilitator of learning. Kathy Short (2009) referred to these attributes as a shared understanding of the term inquiry among educators.

Kathy Short (2009) stated that a shared understanding that inquiry involves learners asking questions and engaging in research leads educators to focus on “getting students to ask better questions and to develop effective research strategies” (p. 11). Short argued this view of inquiry lead to engaging teacher-directed projects and activities that inadvertently violated the structures of inquiry. This argument reflected the problem of practice within this action research study. The inquiry practices within my classroom were engaging for students, yet they remained teacher-driven and more content-focused than process-focused. Short (2009) challenged educators to redefine inquiry as an essential position towards all learning from the perspective that inquiry is limited to a unit or project. A review of the three primary theories was necessary for the teacher researcher to establish and validate the stance on inquiry Short described.

Behaviorist Learning Theory

Learning theories were organized by how learners acquired and retained knowledge. The source of knowledge was central to each theory of how a person learned. Driscoll (2000) reviewed epistemological traditions central to defining learning. Objectivism stated knowledge was external and objective. The objective view of knowledge was the foundation of Behaviorism. This behaviorist movement expanded out of the work of Pavlov (1897), Watson (1913) and Skinner (1948) in the early 20th century. The behaviorist theory of learning assumed learning was an observable change in behavior created through specific stimulus-response associations (Gredler, 2001). According to this learning theory the learner was a passive participant in the learning process who learned through external positive or negative reinforcement.

Cognitive Learning Theory

Later in the 20th century, the behaviorist learning theories moved towards a more cognitive approach to learning. Shannon (1948) found a learner processed information transmitted through experience and interaction much like a computer and stored it for later retrieval. Bruner (1957) stated knowledge was stored and encoded into memory through movement, images, and codes or symbols. Cognitivism shifted the learning focus from the observable behavior to the inner process of "how information is received, organized, stored, and retrieved by the mind" (Ertmer & Newby, 1993, p. 51). Similar to behaviorism, the external environment facilitated learning in the cognitive learning theory (Ertmer & Newby, 1993) Cognitivism additionally included the learner as an active participant influencing the learning process. According to this theory, learning occurred when students organized and related new information to existing knowledge in memory (Ertmer & Newby, 1993).

Constructivist Learning Theory

Contemporary cognitive theorists began to question the objectivistic assumption that knowledge was external to the learner (Ertmer & Newby, 1993). Constructivists believed learners constructed their own knowledge and versions of reality through experiences and interactions with the environment (Bruner, 1990; Prince & Felder, 2006). In the constructivist theory of learning, knowledge was not independent of the individual. Knowledge and understandings were unique to the experiences and background of the learner (Prince & Felder, 2006).

John Dewey (1933) promoted a view of learning based on the pragmatic theory that knowledge was negotiated through experience and thinking. Dewey stated the learning process was a "continual reorganization, reconstruction and transformation of experience (Dewey, 1916, p. 50). Jean Piaget (1972) built on Dewey's ideas of learning through experience with the development his theory of cognitive development. Piaget proposed individuals constructed and built upon knowledge through experience and interaction with the environment. According to Piaget, as a learner interacted with the environment, the individual created schemas or mental modes that lead to learning. Vygotsky (1978) suggested the cultural, social, and language context of the learner and the experience influenced the construction of knowledge.

Vygotsky (1978) supported the foundation for a new version of the constructivist theory of learning with the argument that construction of knowledge was a collective social process. Social interaction improved the construction of meaning for the group and the individual. Vygotsky developed the zone of proximal development (ZPD) based on the value of social interaction in the constructivist theory. People mastered a concept or skill they were not able to master individually through interactions with a more experienced peer or adult in Vygotsky's ZPD. Vygotsky defined the ZPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers" (p. 86).

Current research reiterated the perspective of learning proposed by Dewey (1916), Piaget (1972), and Vygotsky (1978). The National Research Council (2000) found cognitive researchers were in real classrooms testing and refining learning theories more than ever before in history. New research on learning underscored the concept that active learners seeking to understand complex subject matter were better prepared to transfer what they learned to new problems and settings (National Research Council, 2000). Research continued to support practices aligned with the constructivist learning theory according to the National Research Council (2000).

The constructivist theory of learning rejected the idea that knowledge was transmitted to a passive learner. In a review of the literature of Piaget, Dewey, and

Montessori, Ultanir (2012) stated, “constructivists shift the focus from knowledge as a product to knowing as a process” (p.196-197). Terhart (2003) argued the active role of the learner in the learning process placed constructivism in direct contrast with instructivism. According to Terhart, the instructivism theory of learning proposed the teacher was responsible for transmitting knowledge to the learner. In contrast, the role of the teacher in the constructivist theory of learning was to construct environments and create situations in which students could construct meaning and develop understanding (Terhart, 2003).

Researchers suggested the value of incorporating constructivist teaching into the curriculum. Zemelman, Daniels, and Hyde (1993) encouraged educators to create classroom environments that presented students with opportunities to invent and construct new ideas. Twomey Fosnot (1989) suggested a constructivist approach fostered analytical thinking as students questioned, investigated, and reasoned. Le, Lockwood, Steecher, Hamilton, and Martinez (2009) found educational reforms based on the constructivist learning theory consistently led to advances in learner depth of understanding, as demonstrated through evaluations of student processing and problem-solving abilities. A constructivist approach to teaching and learning supported the concept of inquiry as a stance on curriculum that Kathy Short (2009) challenged educators to adopt. The IBO (2014) insisted the constructivist approach could be implemented at all classroom levels through instructional scaffolding and strategies.

There were many challenges to incorporating a constructivist and student-centered learning approach in the classroom. The literature presented a variety of problems that reflected the issues surrounding the problem of practice in this study.

Walker and Shore (2015) described one barrier to implementing the constructivist framework was confusion regarding the role of the teacher. Hmelo-Silver, Duncan, and Chinn (2007) stated this confusion was specifically related to the level of guidance and structure involved in constructive teaching methods. Another important issue in implementing a constructive approach to teaching and learning was the role of content. Hedge and Cullen (2005) and Corrie (1999) argued conflicting views of the role of content knowledge lead educators to implement primarily non-student centered instruction.

Scientific Inquiry as a Socially Constructive Cognitive Process

Inquiry was established as a socially constructivist approach to teaching and learning through the cognitive and constructive theories. According to this perspective, students constructed knowledge through interaction with the environment. Moore (1984) described this process as the *way of knowing*. Learners resolved uncertainties through a cognitive process of examination, critical thinking, and reflection (Barrell, 2016; Perkins, 1992). Constructing knowledge and understanding through scientific inquiry involved a variety of complex intellectual processes (Barell, 2016; Marzano, 2003; Perkins, 1992). Barell (2016) categorized the intellectual process into three levels. Level one was gathering information. Level two involved processing information by analyzing, comparing, solving problems, and making decisions. Level three in Barell's framework was speculating and application of new knowledge.

The shift from knowledge as a product to knowing as a process required the student to be more autonomous in the learning process. An essential element of the constructive learning theory was the learner. The learner created more meaningful and purposeful associations between personal prior knowledge and interactions with the present environment in learning experiences in which the learner had greater agency over the learning process. McCombs (1991) found when students to took more control of the individual and collective learning process they became more motivated to learn. Research found students acquired intellectual skills and values through inquiry-based learning that enabled them to construct new knowledge (Chan, Burtis, & Bereiter, 1997; Bransford, Brown, & Cocking, 1999; Resnick & Nelson-Le-Gall, 1997).

The research provided evidence of a variety of discrepancies between the stance that scientific inquiry was a socially constructive process and the realities of classroom practice. Iqbal and Shayer (2000) and Endler and Bond (2001) reported the development of cognitive abilities among students often did not match the cognitive demands of the inquiry-based learning. A significant amount of research in the literature suggested students and teachers of inquiry-based learning focused more on the outcome of inquiry, not the cognitive process of inquiry (Klahr, 2000; Kuhn, Amsel, & O'Laughlin, 1988; Schauble, 1996). Kuhn, Black, Keselman, and Kaplan (2000) found learners developed performance skills, not cognitive skills when scientific inquiry was focused on the outcome, not the process. They argued it cannot be assumed students inherently had the cognitive skills needed to conduct forms of inquiry learning. Barak & Shakhman (2008) found only a small group of educators promoted the development of cognitive skills as a principal objective of the curriculum.

Researchers addressed these inequities between stance and practice in numerous studies. Kuhn et. al. (2000) described an approach to inquiry in which the cognitive skills of the investigation were explicitly modeled through scaffolding to increase the effectiveness of cognitive habits. Hattie (2007) analyzed 800 research studies and found setting educational goals and establishing a method of self-monitoring progress towards those goals directly impacted achievement. Sullo (2007) discovered routine reflection challenged students to set goals and adjust actions independently.

The social constructivist perspective described by Vygotsky (1978) suggested learning was influenced through interactions with others. The collaborative nature of scientific inquiry-based learning allowed students to develop cognitive skills with more experienced peers, as in Vygotsky's ZPD. Through this perspective, social engagements impacted the context for learning. Lave and Wenger (1991) described the interaction of members of a group to pursue a common goal as a community of practice. Within in the context of the classroom as a community of practice, students acquired the skills necessary to perform practices by engaging in these practices with other members of the community.

The creation of a community of practice appeared to be an essential element of promoting scientific inquiry as a socially constructive process in the science classroom. Wells (2015) found students on a continuum of proficiency levels worked collaboratively to answer questions and develop understanding within a community of inquiry. Wells argued the focus on carrying out an inquiry with the community created a spiral of knowing as students constructed and adjusted meaning, evaluated information and solved problems they encountered along the way. This process of knowing illustrated Vygotsky’s (1978) ZPD, and Lave and Wenger’s (1991) more specific version of ZPD, legitimate peripheral participation (LPP). LPP claimed the learner embodied beliefs and behaviors of the community by interacting with the culture, activity, and context.

Consistent interaction with the community shifted the learner from novice to expert in the practice of the whole.

The contemporary view of science engaged communities of scientists in the continuous improvement and refinement of theory (Duschl & Ellenbogen, 2009; Godfrey-Smith, 2003). Scientists participated in a community of practice that shared linguistic and social norms and patterns of knowing and doing (Anderson, 2007). Similar to Vygotsky's (1978) and Lave and Wegner's (1991) theories of learning, science educators gradually moved students from the fringe to the center of the scientific community as they provided them with opportunities to observe and interact with scientific practices. Students have been found to change their thinking and learning in response to interaction with others (Hall & Rubin, 1998; Wertsch & Stone 1999). Knowledge was not an object in a classroom community practice, but something that evolved as students participated in disciplinary practices (Ryu & Lombardi, 2015).

The research demonstrated that this interconnected relationship between students and practices in a classroom community impacted individuals in negative and positive ways. Enyedy and Goldberg (2004) found the social frameworks and microcultures established in a classroom directly influenced what students learned. Unequal power relations in a classroom hindered student learning. Moje, Collazo, Carillo, and Marx (2001) discovered tensions arose when the cultural and linguistic backgrounds of students differed from their peers and teacher. In contrast, Stanton-Salazar (2004) argued that the social networks of a classroom increased student access to resources and other forms of support as individuals contribute to the whole. Koldner, Camp, Crismond, Fasse, Holbrook, Puntambekar, and Ryan (2003) established expectations for a collaborative community culture. Every member was responsible for helping others learn and the community knew they could depend on each other when needed. Additionally, the teacher was expected to take a facilitative role in the community.

Implementing Inquiry-Based Learning

The International Baccalaureate Organization (IBO) was committed to inquiry as a standard of the IB PYP curriculum because it believed it was the way students learned best (IBO, 2014). Literature from a variety of disciplines conducted in countries across the globe supported that statement. An analysis of 138 studies indicated inquiry-based practices were "associated with improved student content learning, especially learning scientific concepts" (Minner, Levy, & Century, 2009, p.493). IBL was found to not only reduce achievement gaps among various populations of urban schools but also to have a cumulative effect on achievement, increasing success with more exposure to IBL practices (Geier, Blumenfled, Marx, Krajcik, Fishman, Soloway, & Clay-Chambers, 2008).

Research suggested teachers struggled to help students engage in inquiry practices because of confusion over the meaning of inquiry and the appropriate levels of teacher guidance (Ireland, Watters, Brownlee, & Lupton, 2014). Tang and Shen (2005) find it was especially difficult for educators to apply inquiry-based learning models in China where the transmissive instructional models were prevalent. Wisndschitl (2003) found this challenge often stemmed from teachers being required to teach in a way different from how they were taught. Song and Kong (2014) claimed the two most critical factors impacting student ability to engage in the inquiry were the amount of scaffolding provided and the level of student prior knowledge applied. Additional researchers suggested the degree of teacher scaffolding directly impacted student understanding and engagement in IBL (Levy, Aiyebayo & Little (2009); Schmid & Bogner (2015); Wang, Kinzie, McGuire, & Pan (2010).

Inquiry-Based Learning Models

The inductive approach to teaching and learning of the inquiry-based learning (IBL) model was founded in constructivism. The research presented several factors related to the effectiveness of an IBL approach. Song and Kong (2014) concluded in their research that teachers were better able to plan and implement IBL experiences if they understood the theoretical principles behind IBL, agreed upon fundamental principles to apply in the classroom and applied a particular IBL model. Other researchers echoed these findings (Scardamalia, 2002; Song & Looi, 2012; Zhang, Hong, Morley, Scandamalia, & Teo 2011).

A variety of instructional models supported the implementation of IBL. Dewey (1938) described the key steps in the inquiry process as defining a problem, forming a hypothesis, and conducting tests. Song and Kong (2014) developed an IBL model that consists of six elements: engage, explore, observe, explain, reflect, and share. Bybee et al. (2006) created an instructional model comprised of five stages: Engage, Explore, Explain, Elaborate, and Evaluate. Llewellyn (2007) states the 5E model helps "students move from concrete experiences to the development of understanding, to the application of the principles" (p. 135).

Duran, Duran, Haney, and Scheuermann (2011) claimed instructional models were not to serve as a rigid template, but as a reference to support students in their current state of abilities, prior knowledge, and interests. Their research expanded upon the instructional model of Bybee et al. (2006) to include a phase for formative assessment to monitor student understanding and progress through the stages. This phase, titled Express, allowed teachers to modify the stages and experiences to improve the learning process. The Stripling Model (2003) included this express stage as a sharing and demonstration component of inquiry. Stripling described her model as a learning cycle with the following stages: Connect, Wonder, Investigate, Construct, Express, and Reflect.

Inquiry-Based Learning Modes and Frameworks

The inquiry model or cycle has been implemented within the range of structural levels and types of experiences. O’Steen and Spronken-Smith (2012) suggested three categories for educators refer to in developing a framework for IBL. The approach to inquiry within this context had three criteria: scale, mode, and framing. O'Steen and Spronken-Smith (2012) stated scale was necessary to define concerning the scope and sequence of the inquiry experience. Levy (2011) identified two primary frameworks: information-oriented inquiry and discover-oriented inquiry. Students conducted an inquiry for answers that already existed in information-oriented inquiry. Discovery-oriented inquiry promoted understanding through personal questioning, exploration, and discovery.

O’Steen and Spronken-Smith (2012) referred to the structure of inquiry as the mode. The mode of inquiry existed on a continuum between teacher-directed and student-directed of inquiry. Rezba, Auldridge, and Rhea (1999) described the levels along this continuum as confirmation, structured, guided, and open inquiry. Staver and Bay (1987) defined structured inquiry as a teacher-led presentation of a problem and outline for how students can solve it. In guided inquiry teachers guided students through the inquiry process. Teachers provided the questions or problem and students guided the investigation to answer or solve the problem (Staver & Bay, 1987). In open inquiry, student completed the inquiry cycle independently or with peers (Staver & Bay, 1987).

It was essential to consider the levels of inquiry along this continuum to avoid confusion in teacher and student roles in the inquiry process (Walker & Shore, 2015). Aulls and Shore (2008), Biggers and Forbosa (2012), and Bell, Smetana and Binns (2005) developed and described this inquiry continuum in a variety of frameworks. Biggers and Forbosa indicated movement along the continuum occured throughout a series of lessons. Aulls and Shore argued teachers and students continually moved towards and away from the roles at each end of the continuum within one setting. Walker and Shore (2015) found conflicting expectations between students and educators often made the inquiry process problematic.

Inquiry Literacy

Walker and Shore (2015) found in their research that some level of inquiry literacy is necessary for students to be inquirers effectively. Walker and Shore stated elements of inquiry literacy included asking purposeful questions, seeking relevant evidence, realizing there are multiple ways to solve problems, and communicating effectively with others. Holbrook and Kolodner (2000) stated an additional factor of inquiry literacy was the level comfort in the process of active learning.

Walker and Shore (2015) used the term *launcher unit* to illustrate one technique to enhance inquiry literacy for students. The launcher unit was used to explore and practice specific inquiry skills. Content was included in inquiry-based learning after the launcher unit is complete. The launcher unit, as described by Walker and Shore, increased inquiry literacy by giving students explicit modeling and practice of each step in the inquiry process. As a result, students gained the inquiry skills needed for understanding and authentically participating in the inquiry process when content was introduced.

Scientific Practices

In 2000 The National Research Council published a list of skills and abilities considered fundamental for scientific inquiry. The National Research Council revised the 2000 list to establish new goals for science education with *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* in 2012. The three-dimensional framework included specific scientific and engineering practices necessary for an individual to engage in scientific inquiry and engineering design (National Research Council [NRC], 2012). The *Framework* emphasized that students used this set of practices to establish, extend, and refine scientific content knowledge (NRC, 2012). The National Research Council (NRC) stated that the term practices was used instead of skills to suggest that knowledge and skills are required simultaneously for students to engage in scientific inquiry. The NRC and the Next Generation Science Standards (2013) integrated science concepts with scientific practices to move students towards the goal of scientific literacy.

Scientific Literacy

Scientific literacy has evolved with the changing needs of society. The NRC (1996) report claimed science literacy began as attitudes and values established in early childhood, which shaped the development of scientific literacy in adulthood. Bybee (1997) proposed three levels of scientific literacy. Bybee's levels are on a continuum from isolated science knowledge to understanding the interaction between science and society. Many interpretations of scientific literacy were present in the literature. In science education the term scientific literacy emphasized the application of scientific content knowledge to different contexts and situations in conjunction with scientific ways of thinking (Harlen, 2010; Osborne & Dillon, 2008; Yore, Pimm, Tuan, 2007). Driscoll (2005) argued that science education that immersed students in authentic practices of scientists was critical for students to develop the knowledge and skills necessary for future success in the sciences. The *Framework* published by the NRC (2012) and the NGSS (2013) designed scientific practices, concepts, core ideas, and standards to prepare students to be successful citizens in college, the workplace, and society.

The National Research Council (2012) established a set of practices out of the perspective that the work of science develops theory and knowledge through unique ways of investigating, talking, writing, and reasoning. The eight scientific practices the considered essential to the science and engineering curriculum were:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

In the *Framework* the committee proposed that these practices represented the essential elements of scientific inquiry that science educators often found too ambiguous to effectively implement in classroom practice (NRC, 2012). The National Research Council (2012) presented the practices as non-linear, non-sequential steps that were not taught in isolation from science content (NRC, 2012). The primary objective of the National Research Council (NRC) was for students to develop the aptitude and propensity to employ the practices as needed to support learning and demonstrate understanding of science and engineering.

Analyzing and interpreting data. Contemporary scientists and researchers established science as more than the act of collecting data to describe observations, but as the practice of answering questions of how and why the world works as it does (Sandoval & Millwood, 2005). The NRC (2012) claimed raw data did not speak for itself. Scientists used tools to identify features and patterns in the data to derive meaning (NRC, 2012). The NRC suggested visualization techniques such as tables and graphs made patterns more obvious for students to make sense of data collected during investigations. The practice of analyzing and interpreting data at the elementary level, according to the NRC, involved the purpose of recording observations in drawings, words or numbers and sharing those observations with others. As students gained proficiency in the collection of observations, the NRC suggested they would then begin recording it in forms that facilitated interpretation such as tables and graphs.

The role of data in the science classroom has not always been clear and consistent. Research found students were more likely to interpret data as a fact than as a constructed meaning that was open to interpretation (Sandoval and Cam, 2011; Manz, 2016). In many classrooms students described observations or collected data compliantly, with little need to make sense of that data (Duschl, 2008). From this perspective the raw data was the goal of the investigation and was analyzed or interpreted to make connections back to the original question (McNeill & Berland, 2016).

Research found student proficiency in analyzing and interpreting data in graphs and tables increased with repeated practice, not cognitive ability (Monk, 2003; Roth & McGuinn, 1997). Arias and Davis (2017) suggested it may be necessary for teachers to explicitly discuss data features and various forms of data representations with students. Verbal and visual prompts, such as questioning and making patterns visual, have been found to successfully facilitate student practice in analyzing and interpreting data (Herenkohl, Palinscar, DeWater, & Kawasaki, 1999; Reiser, Berland, & Kenyon, 2012; Zembal-Saul, McNeil, & Hershberger, 2013; Zembal-Saul, 2009).

Engaging in argument from evidence. An argument is a statement that answers a question or problem, usually consisting of three components: claim, evidence, and reasoning. (Zembal-Saul, McNeill, and Hershberger, 2013. The NRC (2012) defined engaging in argument from evidence for young students as justifying the explanations they construct and defending their interpretations of the data. Argumentation occured when students shared, processed, learned about and evaluated the arguments and ideas of a classroom community (Driver, Newton, & Osborne, 2000; Michaels, Shouse, Schweingruber, & National Research Council, 2008). The goal of argumentation was for students to identify elements of agreement and proficiency or disagreement and deficiency as they discussed arguments generated from evidence (Chen, Hand, & Norton-Meier, 2016).

In much of the research argumentation was defined as a form of dialogue in which the primary intent is to justify or persuade others to understand a claim (Duschl & Osborne, 2012; Erduran & Jimenez-Aleixandre, 2007; McNeill & Pimental, 2010; Shemwell & Furtak, 2010). Driver, Newton, and Osborn (1988) found argumentation occured when alternative claims were evaluated through dialogue.

Argumentation also served to develop student ability to construct meaning and to evaluate the possibility of alternative solutions. Kuhn (1991) found students developed reasoning skills as they considered ideas or claims different from their own. Nussbaum (2011) claimed scientific knowledge emerged as individuals compared, critiqued, and revised ideas through collaborative and critical argumentation. Chin and Osborne (2010) found students collectively constructed meaning as they critiqued connections between evidence and scientific arguments during classroom discussions. Despite the benefits of critique and argumentation in the research, students rarely had the opportunity or time to construct or critique ideas based on scientific evidence (Erduran & Jimenez-Aleixandre, 2007; Krajcik & Merritt, 2012).

The literature found the practices of generating arguments and engaging in argumentation were not present in many elementary classrooms due to what Osborne (2010) claimed was an overemphasis on what was known over how it was known by teachers, curricula, and textbooks. Sampson & Blanchard (2012) found teacher perceptions of student abilities to engage in argumentation limited student experiences and practice. Zembal-Saul, McNeill, and Hershberger (2013) found most elementary science lessons focused on fun, hands-on activities, with little connection to scientific practices or concepts. Researchers argued that opportunities to generate scientific arguments were often not provided to early elementary students because it was assumed that their reasoning abilities and conceptual knowledge were too limited for them to engage in scientific practices (Chen, Hand, & Norton-Meier, 2016; Lehrer & Schauble, 2006; Metz, 2011). Student proficiency in generating and defending arguments was also impacted by the quality and nature of interactions within the classroom community (Berland, 2011; Evagorou & Osborne, 2013).

The NRC claimed elementary students needed instructional support to provide scientific reasoning or references to evidence in addition to their claims. As students gained proficiency in generating scientific arguments, they increased the ability to provide a wider range of reasons or evidence for more advanced arguments (NRC, 2012). Instructional supports and strategies introduced by researchers and educators provided support in student development of scientific arguments. One structure of a scientific argument included a claim that answered the question, evidence that included scientific data to support the claim, and reasoning that explained how the evidence supported the claim (McNeill, Lizotte, Krajcik, & Marx, 2006; Zembal-Saul, McNeill, and Herschberger, 2013). Del Carlo and Flokstra (2017) found students engaged in argumentation with greater success when the process of generating an argument was introduced without scientific concepts.

Instructional Scaffolds

Instructional strategies to support students in their progression towards proficiency in inquiry and scientific practices were present in the literature. Many of those strategies involved some form of scaffolding Bruner (1976) described guided participation within Vygotsky's zone of proximal development as scaffolding. If students were not intrinsically able to exercise the cognitive skills needed to conduct forms of inquiry as Kuhn et al. (2000) contended, scaffolding served to develop those skills. Lakkala, Lallimo, & Hakkarainen (2005) discovered scaffolding was essential for students to develop metacognitive awareness of inquiry strategies.The model of cognitive apprenticeship gradually shifted the responsibility of the inquiry process from the teacher to the student.

Cognitive Apprenticeship

Similar to craft apprenticeship, cognitive apprenticeship methods immersed the student in the authentic process and practice of cognitive skills through activity and social interaction (Brown, Collins, & Duguid, 1989). Collins, Brown, and Holum (1991) described cognitive apprenticeship as making thinking visible. Collins et al. explain,

> In cognitive apprenticeship, one needs to deliberately bring the thinking to the surface, to make it visible, whether it's in reading, writing, or problem solving. The teacher's thinking must be made visible to the students, and the student's thinking must be made visible to the teacher. (p. 3)

Duncan (1996) described the cognitive apprenticeship method as a scaffold that was designed to provide less assistance as the student gained experience and competency in solving problems. Throughout the scaffolding Duncan referred to, the teacher described what she was thinking and doing, why she was taking specific actions, and how she corrected herself as she made mistakes in the process. Cognitive apprenticeship methods, such as the one Duncan described, have been studied across many disciplines. However, much of the literature demonstrated the use of this approach in the subjects of math, reading, and writing (Fishbach, 1993; Flower, 1993; Hayes & Flower, 1980; Palinscar & Bron, 1984).

The use of cognitive apprenticeship had the potential to increase student scientific literacy to improve inquiry-based learning and scientific practices. The primary element of cognitive apprenticeship was the act of scaffolding thinking or inquiry skills through the gradual release of responsibility.

Metacognition

An inquiry, as described in the literature, was primarily defined as a learning process in which learners construct meaning through experience and discovery. The inquiry process was unique to the individual. The cognitive skills used in the construction of knowledge were often not visible through external behaviors. Consequently, metacognitive awareness was essential for students to successfully regulate and monitor the development of inquiry and cognitive skills unique to the learner.

Metacognition, as defined by Flavell (1976), was "one's knowledge concerning one's own cognitive processes and outcomes or anything related to them" (p. 232). Regulation of cognition involved planning, monitoring, and evaluating thinking (Hacker, 1998; Israel, 2007; McCormick, 2003). Research conducted by Ristic (2014) found students who demonstrated higher levels of metacognition were more self-directed and constructed deeper understandings in the inquiry process.

Ritchart and Perkins (2008) developed a variety of thinking routines to make thinking visible for students. They discovered that effective thinkers externalized their thoughts, making the thinking that was invisible to others, and even themselves, visible. Students were able to make their thinking visible to peers through talking, writing, or drawing. Richart and Perkins believed learning was a consequence of thinking and thinking was a social endeavor, making the act of making thinking visible to others a critical element to learning.

Anchor charts were introduced as a visual reference or cue to support students in guided or independent practice of a skill, strategy or process (Harmon & Marzano, 2015). Newman (2010) suggested an anchor chart made thinking visible when it was used to record strategies, processes, cues, or guidelines of the thinking and learning process. Anchor charts posted and accessible for student reference reminded students or prior learning and served as a tool students could use in future problem solving or discussions (Newman, 2010).

Scientific Discourse

An additional tool discussed in the literature employed in classrooms to make thinking visible was discourse. Michaels, Shouse, and Schweingruber (2008) argued oral and written communication was the primary means of making thinking public. Osborne (2010) found effective discourse enhanced conceptual learning and depth of understanding for students. Dawes (2004) argued that students advanced in science achievement when they learned and practiced listening and speaking in scientific contexts. Kelly, Crawford, and Green (2001) discovered student discussion and argumentation skills, not level of subject knowledge, had the greatest impact on the proficiency level of academic discourse.

Gee (1989) defined discourse in two forms. Discourse with a capital *D* was defined as a way of being that integrates “words, acts, values, beliefs, attitudes, and social identities as well as gestures, glances, body positions, and clothes” (Gee, 1989, pp. 6–7).

Discourse with a lowercase *d* was the language associated with a particular Discourse (Gee, 1989). Throughout history the field of science developed its own Discourse community that included specialized language, beliefs, and identities associated with its practice. Research suggested differences in Discourse often excluded students from school-based and discipline-based communities of practice (Gee, 1993; MacKay, 2003; Zwiers, 2007). Successful science education based on the model of Discourse within the scientific community must include students in communication to construct, negotiate, and refine reasoning of various forms (Duschl & Ellenbogen, 2009).

Studies have shown that students must be taught the norms, functions, and literacy necessary to explore and challenge ideas, evidence, and argument (Barron & Learn, 2003; Blatchford, Kutnick, Baines, Galton, 2003; Mercer, Wegerif, Dawes, 1995). Structured talk and discussion methods found in the literature emphasized the social constructivist perspective by Vygotsky (1978) that individuals construct meaning through social interaction. Students required social integration through these various forms of structured and productive talk to learn and practice the norms and language specific to academic Discourse communities (Gee, 1993; MacKay, 2003; Zwiers, 2007). Structured talk with clear norms and defined outcomes provide students with a purpose for debate and discussion (Mercer, Wegerif, Dawes, 1995; Osborne, 2010).

Open-ended questions and prompts encouraged students to increase discourse proficiency in numerous studies involving young learners. Teachers used prompts to scaffold purposeful strategic conversation for young learners by asking open-ended questions and open-ended statements in a study by Wasik and Iannone-Campbell (2012). Many researchers argued open-ended questions lead whole-class discourse down a responsive pathway that encouraged students to elaborate on and deepen their thinking (Colley & Windschitl, 2016; Minstrell & van Zee, 2003; Nystrand, Wu, Gamoran, Zeiser, & Long, 2003). Colley and Windschitl (2016) found when teachers used open-ended questions, prompts to follow up, and questions to prompt student-to-student comments rigorous student discourse was generated. Wasik and Hindman (2013) discovered students learned more academic vocabulary when teachers allowed multiple students to provide a variety of possible answers to open-ended prompts. Other research found teacher prompts encouraged students to employ reasoning strategies (Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006)

A variety of tools provided flexible scaffolding for students to effectively express and exchange ideas through dialogue. These scaffolds built student capacity to make the learning and thinking process visible through talk (Hammond, 2015). Conversation protocols provided students with structured steps for productive academic talk. These protocols helped students to collaborate by developing the ability to actively listening and give meaningful feedback (Zwiers & Crawford, 2011). Sentence starters and linguistic frames were found to successfully support student talk (Fisher, Frey, & Rothenberg, 2008; Graff & Birkenstein, 2006; Zweiers, 2007). Resnick (1995) presented the concept of accountable talk as guidelines for academic conversations that included norms and linguistic frames. Accountable talk employed guiding questions and clearly defined norms that provided a structure for students to ask for and provide evidence to support their thinking (Michaels, O'Conner, Hall & Resnick, 2002).

Historical Context

The primary source of conflict within the problem of practice in this study was the required merging of two curriculum perspectives that were contradictory in nature within the first-grade classroom. Placing the curriculum perspectives in historical context was helpful. The inquiry-based approach was part of a long historical tradition emerging from philosophers of Ancient Greece. The instructional-based approach, referred to as traditional teaching, in the United States involved the transmission of knowledge to the learner from someone who was more knowledgeable. The age of industrialism and the era of required standardized testing sustained the use of this approach in America.

The transmission–based method was seen in the rise of formal school systems and universities of the 12th century Europe. The Roman Catholic priests knowledge was seen as the authority. In the 12th century Europe the Roman Catholic priests served to transmit knowledge, of what was then referred to as revealed truth, to the public (Monroe, 1925). Individuals were considered scholars when they gained knowledge by repeating and memorizing scripture or biblical principles.

Elements of in inquiry-based learning (IBL) were present in the ancient teachings of many philosophers of Ancient Greece. The highest goal for Socrates and other philosophers was the possession of truth and knowledge that could be fully supported by arguments (Perin, 2001). Socrates developed a systematic questioning process to discover fundamental truths about the world. Through this process Socrates investigated many of the commonly held assumptions of the time were flawed and even illogical. (Friesen & Scott, 2013)

The initial development of the American common school in the 18th century established the school as a powerful tool for the advancement of society. The historical account of the common school movement by Spring (2014) described the evolution of education as a means to advance society and create a united American culture. In the 18th and 19th centuries, the common school was used to conform youth to the values and behaviors Anglo-Americans deemed culturally superior according to Spring. Noah Webster created the first textbooks of the common school. The textbook was intended to create a unified culture that spoke the same language and held the same moral and political values (Spring, 2014). Many agreed that the primary purpose of the common school system was to shape children into patriotic, ethical and responsible citizens based on a set of predetermined principles and beliefs, such as those in Webster's textbooks (Spring, 2014).

In the early part of the 20th century, John Dewey was a primary figure in the resurgence of the progressivism movement in education. Dewey (1933) proposed that knowledge was constructed from experience. Dewey’s theory of learning formularized and clarified constructivism (Dewey, 1916). Spring (2014) stated, “Dewey’s methods emphasized student interests, student activity, group work, and cooperation-methods premised on the idea that the school had to serve a new social function in helping students adjust to an urban and industrial society” (p. 252). The progressive theories of Dewey were never accepted standard public classroom despite his efforts to convince the National Education Association and other groups (Spring, 2014)

During the early part of the 20th century, the new industries such as steel manufacturing, petroleum refining, and electricity emerged. A new industrial economy radically altered the way Americans lived. This shift in the American culture led educators and civic leaders to debate over the role of education in this new economy. Spring (2014) stated the greatest concern in education was with social efficiency due to the economic and social issues of the time. Franklin Bobbitt saw education as a functional tool to train children to contribute to an industrial society. Bobbitt's Social Efficiency ideology focused on the behavioral capabilities of the potential adult that will fulfill the social and economic needs of the society (Schiro, 2013). The public school transitioned to an efficient system of vocational and differentiated education into the twentieth century to develop human capital that would meet society's needs for a specific labor force (Spring, 2014).

Edward Thorndike and William James advocated teaching methods based on the science of human behavior during the start of the 20th century. According to Spring (2014), Thorndike translated the relationship between stimulus and response to concepts of teaching and learning. Thorndike viewed education as "a science concerned with the control of human behavior" (Spring, 2014, p. 257). The classroom practices of exercise and drill were highlighted as scientific methods of instruction based on Thorndike's "fundamental laws of change" (Spring, 2014, p. 257). Spring described the development of scientifically constructed tests to measure the behavioral response of the learner. Thorndike, like Dewey, "had a social vision related to the educational methods he advocated" (Spring, 2014, p. 258). Thorndike claimed tests and measurements could scientifically determine the appropriate social role of each person by efficiently matching individual talents to social needs (Spring, 2014).

The priority for nationalism continued to influence the curriculum into the 20th century. Flinders and Thornton (2013) attributed curriculum reforms of the 1950s and 1960s to the growing fear that America was not prepared to compete with the technological and scientific advances of other countries. The launch of *Sputnik I* by the Soviet Union in 1957 indicated to many “Americans that America was losing the technological and military race" (Spring, 2014, p. 369). In response to public fears and turmoil, the government increased its leadership role in educational policies, allocating funds to programs "considered essential for controlling and developing human resources for the Cold War" (Spring, 2014, p. 369).

A main recipient of government allocations at that time was The National Science Foundation (NSF). Much of the curriculum research from the NSF promoted the concept of the active inquirer, as opposed to the traditional passive recipient of knowledge. The NSF developed many curriculum projects in the late 1950s and 1960s based on this concept such as “the Science Curriculum Improvement Study (SCIS), the Elementary Science Study (ESS), the Physical Science Study Committee (PSSC Physics), and the Earth Science Curriculum Project (ESCP)” (Lawson, 2010, p. 85). Scholars within this curriculum movement asked "students to form and test their hypothesis and conduct experiments mimicking their own" (Symcox, 2002, p. 20).

Textbooks and science methods were created in response to this curriculum movement. Heiss, Aburn, and Hoffman (1950) created a method for inquiry learning called the learning cycle based on John Dewey's (1933) whole act of thought. Other methods for inquiry learning developed during this movement were the problem-solving method by Washton (1967) and the inquiry method by Kuslan and Stone (1968).

In response to the increased funding for curriculum research in areas such as science and mathematics was an increased effort to evaluate the school curricula. The means-end model developed by Ralph Tyler (2013) in 1949 became the model for curriculum development. Tyler's approach defined educational objectives based on "the kinds of changes in behavior that an educational institution seeks to bring about in its students" (p. 61). This same approach was later used to assess the student realization of those objectives through new nationally standardized tests (Madaus, Stufflebeam, & Scriven, 1993).

In the 1960s many believed education was not able to produce talent to serve the national economy because of inequality and poverty. In 1964 President Johnson announced a war on poverty (Spring, 2014). Siegfried Engelmann investigated how children learned and determined teacher-led modeling, reinforcement, and feedback directly impacted learning (Joyce, Weil, & Calhoun, 2000). Out of these findings Engelmann developed the Direct Instruction model. In a study of over 75,000 students, direct instruction was found to be a far superior instructional method than all other models (Bock, Stebbins, & Proper, 1977).

The National Science foundation initiated large-scale science curriculum projects in 1964 (Duschl, 1990). A major innovation introduced along with the 1960s reform movement was a shift from an emphasis on methods of science that students memorized to processes of science. The science processes included specific actions considered fundamental to thinking across the sciences (National Research Council, 2007). The process skills included observing, clarifying, measuring, inferring, and predicting. Also included in the newly reformed science curriculum was a focus on making hypothesis and designing and carrying out experiments.

The accountability movement grew in the 1970s from the use of Tyler's objectives and the use of nationally standardized tests (Spring, 2014). The accountability movement emphasized the totality of educational effectiveness "rests solely on measurable gains in student test scores resulting from teachers' instructional endeavors" (Schiro, 2013, p. 83). This focus on standardized tests and increased emphasis on basic facts and skills overshadowed the growing amount of research supporting student-centered approaches such as IBL.

In 1983 a report entitled *A Nation at Risk* was made public by the U.S. Department of Education. The report stated the prosperity, civility, and security of America were threatened by mediocrity in subjects such as reading, math, and science (National Commission on Excellence in Education, 1983). As a result of the recommendations in the report and the increased focus on raising standardized test scores, inquiry-based practices were replaced with traditional direct instruction in science and all other subject areas. In the 1990s, *Benchmarks for Science Literacy* and *The National Education Standards* were developed to guide science curriculum that provided the opportunity for students to learn content that would be tested on state assessments (National Research Council, 2007).

The National Research Council (NRC) shifted the curriculum emphasis from process to practice in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* in 2012. The scientific practices were developed out of advances in understanding of how science progresses and research on how students learn

(Bybee, 2013). Bybee (2013) argued the practices reinforced the need for science education to actively involved students similar to inquiry-based initiatives. Practices were learning outcomes and instructional strategies that students develop as a result of practice, but also employ as a means to a learning outcome (Bybee, 2013).

Education continued to be critical to the economic prosperity of individuals, communities, and countries. In the twenty-first century, according to Spring (2014), most of the world's policy leaders promoted education as the solution for major economic concerns such as unemployment and improved living conditions. Darling-Hammond (2008) highlighted a shift in economic and labor needs as the United States moves into the 21st century. According to Darling-Hammond 95% of jobs in the 20th century required employees to follow necessary procedures to complete low-skill manual labor. In the 21st century, this category of labor only made up approximately ten percent of jobs within the United States economy. This shift demanded a change from a perspective based on the industrial model to one based on the labor needs of the twenty-first century.

According to speaker Tony Wagner (2015), "since information is readily available to everyone content knowledge is no longer valued in the workplace. What matters most in our increasingly innovation-driven economy is not what you know, but *what you can do* with what you know" (Wagner, 2015, p. 27). The Partnership for 21st Century Learning (P21) was developed in 2002 in response to the shift in occupational needs at the start of the twenty-first century. The P21 coalition of leaders in education, business, and policy-making identified a set of skills they considered essential for success, along with content mastery, in the twenty-first century. Included in the P21 framework is a focus on creativity, critical thinking, communication, and collaboration as essential to preparing students for the future according to the *Framework for 21st Century Learning* (2016).

In addition to an effort to refocus education on creative and critical thinking skills, the digital age also increased the use of national data collection through standardized testing. Spring (2014) stated, “What was lacking in this earlier time were computers that could process national educational data. In the twenty-first century, this was no longer the case” (p. 453). The data system strengthened the accountability movement of the 20th century in the 21st century. Curriculum reform efforts of the twenty-first century advocating for a uniform curriculum using uniform tests to measure student achievement was reminiscent of the common school agenda in the 18th century to produce a unified culture. Spring stated the result of reducing students to statistical data was “an authoritarian school system dedicated to serving the interests of multinational corporations” (p. 453).

As Malaguzzi (1998) wrote, education must continuously address the transformations in the human relationships, economy, sciences, arts, and customs of society because they influence "how human beings-even young children-‘read' and deal with the realities of life" (p. 60). This historical context was, therefore, a starting point for the transformations that occurred in the classroom. The curriculum conflicts rooted in the history of educational reforms did not serve to dictate our classroom curriculum. My students and I addressed this history and the historical relationships within our society in our negotiations with the curriculum in our classroom.

Impact of Historical Context upon Inquiry-Based Learning

Understanding the historical roots of inquiry-based and content-based learning was relevant to this study. The Socratic tradition uncovered several elements missing from present-day use of inquiry-based learning. Socrates employed a method of inquiry in which he actively engaged in the conscious investigation through questioning and dialogue. Inquiry wasn't an investigation to receive knowledge from someone who was more knowledgeable. Nor were his investigations sporadic. For Socrates, seeking knowledge through inquiry was a means of living "more ethically and consciously in the world." This perspective on inquiry echoed Kathy Short's (2009) concept of *inquiry as a stance on curriculum* that initiated this literature review.

In the Socratic method of inquiry both the teacher and the students were actively engaged in the process of asking questions and pursuing answers through continuous dialogue and investigation. Ross (2003) highlighted that the Socratic method of inquiry was "a shared dialogue between teacher and students in which both are responsible for pushing the dialogue forward through questioning" (p. 1) The concepts of the Socratic tradition were reflected in research conducted by Hmelo-Silver, Duncan, and Chin (2007). They concluded that students experience greater success constructing meaning and solving problems when the teacher co-participated in the inquiry process with guidance and scaffolding.

Spring (2014) described the development of the educational curriculum and structure of the twentieth century as a reflection of the economic needs of dominant societal groups. The teacher-centered model of learning through transmission of knowledge was an effective method in producing a product that demonstrated knowledge by a change in behavior and an accumulation of facts. It developed into the default mode of teaching for a society in which education served to produce people who will contribute to the advancement of the economy.

Sleeter and Stillman (2013) contended the current era of standardized testing served to enforce compliance with the curriculum and structure of the dominant social groups. The impact of standardization was the collective expectation of conformity. The problem with compliance was that people were not standardized. Ken Robinson (2015) stated:

> Strict compliance is essential in manufacturing products, but people are different. It's not just that we come in all shapes and sizes. In the right circumstances, we are also highly imaginative and creative. In a culture of compliance, these capacities are actively discouraged, even resented. (p. 37)

Sleeter and Stillman (2013) argued the issue of curriculum was about more than student learning because it simultaneously declared whose knowledge was the most legitimate. Robinson (2015) provided many examples of schools that viewed students as inquirers, innovators and voyagers instead of products and data points. He contended students flourished and gave their best in these schools because they were viewed as human beings and contributors to the learning process.

The historical context of the curriculum supported the purpose and relevance of this study. Compliance with a curriculum focused primarily on content implicitly forced students to conform to only one perspective. Populations of people associated with a multitude of diverse cultures, races, religions, and sexual orientations were not included in the dominant definition of normal within the American society. I had an ethical responsibility to honor the prior experiences and unique ways students constructed meaning. Education was not the mechanistic process the social efficacy ideology proposed. In the constructivist view, the social efficiency ideology suggested a false assumption that all students were able to create meaning and demonstrate understanding in the same manner. Inquiry-based learning recognized the unique learning process of each student, positioning the problem of practice within this study was relevant to the current curriculum conflicts of the public school.

Conclusion

This chapter explored the theoretical framework of this study. Understanding the constructivist approach to learning established inquiry as a stance on curriculum as Short (2009) described, not as a learning activity isolated from the curriculum or the learner. The research and literature regarding inquiry-based learning and teaching practices presented in this review supported the priority for IBL as a classroom practice. Scientific practices clarified the behaviors necessary for scientific and inquiry literacy. It also suggested the appropriate methods to address the stated problem of practice.

Research described the challenges experienced by teachers implementing inquiry and scientific practices stem from a variety of sources. A primary source of difficulty found in the literature was tension related to the role of the teacher in an educational system that has been traditionally content and teacher-driven (Corrie, 1999; Hedge & Cullen, 2005; Walker & Shore, 2015). Researchers argued that educators are better able to address these challenges when they established fundamental principles to guide learning and create an instructional framework based on those principles.The literature presented in this review provided the foundation of key principles used to develop instructional scaffolds in this study.

While a variety of research described the benefits of scientific practices in secondary classrooms, insignificant research is available on models implemented in primary or first-grade classrooms. This gap in the research establishes precedence for investigating the impact of scientific practices upon the development of inquiry-based learning of first-grade students. This DP will help to contribute to the literature, providing teacher-researcher and student-participant experiences in the development of inquiry and scientific literacy within a first-grade classroom.

Chapter 3:

Methodology

Introduction

The purpose of this action research study was to explore how instructional strategies impacted the quality of scientific and inquiry-based practices within the first-grade classroom at the study site. As the teacher researcher, I examined my teaching practices and their effects on student learning to initiate positive change within the boundaries of the classroom environment (Mills, 2014). Action research principles and methods as defined by Mertler (2014) supported the purpose of this study.

Problem of Practice

The science and engineering practices of the Framework for K-12 Science Education created by the National Research Council (2012), the South Carolina Science and Engineering Practices (2014), and the EQUIP protocol developed by Marshall, Horton, and White (2009) provided a precise definition of quality guided inquiry-based practices for teachers and students. Based on the EQUIP rubric developed by Marshall, Horton, and White (2009), the methods I used in my classroom before this study rarely demonstrated proficient or exemplary level inquiry-based instruction or learning. Students were able to ask questions and carry out scientific investigations to answer questions.

The level of student proficiency in the inquiry process began to fade when students were encouraged to analyze and interpret data to generate arguments based on evidence from those investigations. When this disruption of student-driven inquiry occurred, I shifted from student-driven to predominantly teacher or content-centered instruction.

The action research methodology was used to evaluate the impact of instruction focused on the specific scientific practice of generating arguments using collected data and observations as evidence. The systematic approach of the action research methodology described by Stringer (2007) enabled me to develop practical and relevant solutions to a daily problem. A qualitative case study design was employed to provide a deeper understanding of the elements that act as barriers or supports in the progression towards student proficiency in generating arguments from evidence. This chapter gives a description and justification of the procedures and tools used in each stage of the action research cycle to investigate the problem of practice and its research questions.

> *Research Question 1:* What is the impact of instruction focused on the development of student proficiency in generating an argument from evidence in a first-grade classroom?
>
> *Research Question 2:* How does a focus on specific science practices maintain a proficient level of scientific inquiry in a first-grade classroom?

Action Research Methodology

Action research was the most appropriate methodology to address the stated problem of practice. Action research is a process for teachers to better understand and improve upon the quality of their instructional methods, strategies, or materials by testing and tracking their effectiveness with their students (Cullen, Akerson & Hanson, 2010; Mertler, 2014). The framework of this study was developed through Mertler's (2014) four-step, cyclical process of planning, acting, developing, and reflecting. Mertler regards the following stages as flexible and potentially without a definite end. This chapter details my plan for each phase of the action research cycle with the understanding that some phases or steps may coincide or repeat during the study. Mertler (2014) lists the elements of the planning stage as developing a research plan after gathering information and reviewing the related literature on an identified topic. The evolution of the research plan for this action research project began with a broad school-wide goal of increased inquiry-based student-led teaching and learning as a result of an International Baccalaureate Primary Years Programme (IB PYP) evaluation. The findings from this study will be used to guide the direction of future investigations through the continuation of the action research cycle.

Design of Study

A qualitative case study design was used to explore the process of increasing the quality of teaching and learning practices in my first-grade classroom. The case study design was defined by Creswell (2013) as the exploration of a bounded system over time through data collection and analysis. The research question of this study sought to discover the impact of my teaching practice when the focus of my instructional decisions and interventions was student proficiency in generating an argument from evidence. In addition to the particular contexts of the instructional methods of an inquiry unit across a six-week timeframe, my first-grade students and the location of my classroom bound the study.

As an educational researcher, Merriam (2009) found the qualitative case study design provided a framework for educators to explore a topic when the priority was the process, not the outcome. Yin (2014) stated that researchers were best able to explore how a phenomenon occurred without manipulation of relevant behaviors through a case study design. This design allowed for the study to evolve as participants interacted, which aligned with the interpretivist paradigm guiding this study. The qualitative case study design was an appropriate strategy to explore the conditions and interactions within the specific context of the structured inquiry practices with my first-grade students in my classroom.

Unit of Analysis

The phenomenon of how my students and I experienced instructional strategies focused on developing student proficiency in generating an argument from evidence was the unit of analysis for this study. This case was bound by the context of time, setting, and instructional methods. It was critical that I define the unit of analysis and its contextual conditions to create a distinction between data about the case and data external to the case (Yin, 2014).

The study site was an International Baccalaureate Primary Years Program (IB PYP) school in South Carolina. Students at the study site were residents of a rural community from several small towns. The percentage of students who qualified for free or reduced-priced meals was approximately forty percent (FSSRP, 2013). Seventy-six percent of currently enrolled students identified themselves racially or ethnically as White (South Carolina Department of Education [SCDE], 2015). Twelve percent identified themselves as Black, while eight percent identified themselves as Hispanic

(SCDE, 2015). Four percent of students identified themselves as other ethnicities (SCDE, 2015).

The primary participants of this action research study were the first-grade teacher researcher and 17 first-grade student-participants in her classroom at the study site. As the teacher-researcher, I was National Board certified and had received training on inquiry-led instructional practices from the International Baccalaureate Organization at IB PYP conferences and workshops.

Context

The role of context was embedded within the constructivist framework Mertler (2014) presented in his work on action research and within the qualitative case study that Merriam (1998) and Stake (1995) described. Discoveries and interpretations that occurred through the process of data collection and analysis were rooted in the context (Crabtree & Miller, 1999). It was impossible to separate the socially constructed experiences and interactions between the participants and participant-researcher. Lincoln and Guba (1985) found the investigator, the participants, the phenomenon investigated, and the social and historical context of a study were interactively linked. An understanding of the specific research site, participants, and researcher was necessary if the discoveries and findings of this study were to be applied to other cases or settings (Willis, 2008).

Evolution of the research question. In collaboration with my first-grade Professional Learning Community (PLC) at the study site, I created six inquiry-based units of study to support students in constructing meaning and building connections within six overarching concepts. Throughout the unit addressing the overarching concept of patterns I observed teaching and learning practices gradually transitioned from student-driven to content-driven. I conducted an informal survey of first-grade teachers within the PLC and found my colleagues and I used and observed inquiry-based practices less than thirty percent of the instructional time. Gathering this information led to a review of related literature described in greater detail in Chapter Two. The research supported the benefits of student-led inquiry-based practices, yet offered few investigations into the impact of specific instructional designs or structures on those practices within a classroom.

I discovered the National Research Council (2012) and the South Carolina Science and Engineering Practices (2014) presented scientific practices that clearly defined the behaviors of each stage in the inquiry process. The problem of practice narrowed from a need to improve general inquiry practices to a need to strengthen specific scientific practices to increase the quality of inquiry within my classroom. This DP intended to explore and understand the unique and distinct experiences that acted as barriers to or served to advance the quality of the scientific practices within the inquiry process in my classroom. The purpose of this study focalized to specifically investigate how instructional methods designed to support the science practice of analyzing and interpreting data in connection with the practice of generating an argument from evidence hindered or supported student demonstration of those practices. The research questions were revised to reflect that purpose.

Social justice issues of the research site and participants. SC state-mandated standardized test scores revealed a significant achievement gap between students at the study site who qualify for free or reduced-priced meals and those who do not (Fork

Shoals School, 2013). In a study of over seven thousand students, Wenglinsky (2002) found teacher quality and classroom practices have an equal to or more significant impact on student achievement than the students' socioeconomic status. Teaching practices positively associated with student achievement in Wenglinksy's study included engaging students in higher-order thinking skills, hands-on learning, solving unique problems, and authentic assessments. Inquiry-based instruction engaged students in these elements and provided a learning environment that had the potential to bridge this achievement gap between students of different socioeconomic statuses in the rural community.

Role of the researcher. Throughout this project, I served as both the teacher-participant and researcher. The purpose of the researcher in the interpretive approach was to be a participant observer, not one who was positioned above or outside of the phenomenon (Carr & Kemmis, 1986). Constructivist researchers acknowledged the personal, cultural, and historical experiences that influenced their interpretations (Creswell, 2014). Anderson, Herr, and Nihlen (2007) claimed researchers identified and understood the impact on the trustworthiness of their findings and the ethics of the research process when they reflected on their positionality within the context of a study. Acting as both teacher-participant and researcher gave me insider knowledge and understanding of the student-participants and their broader social and cultural context. In addition to being both teacher-participant and teacher-researcher, I was a member of the school community and a parent of two students at the study site. This level of insider knowledge and understanding was beneficial when making adjustments to the unpredictable events and needs of the classroom that naturally occurred throughout the research process.

While there were advantages to this position as an insider, there were potential disadvantages. The primary drawback to my insider position was the risk of bias when analyzing data or interpreting results. To reduce this bias, I remained open to all suggestions, perspectives, and ideas presented by participants and colleagues throughout the process. The other disadvantage came from my vested interest in the results (Punch & Oancea, 2014). This project stemmed from a professional desire to increase inquiry-based student-led teaching and learning within my classroom and my school. Methods that focused on science practices as a means to improve the proficiency level of inquiry-based learning were not typical within my school culture. Instructional approaches to increase the use of analyzing data to generate arguments for early elementary students were prevalent in the literature. To address the potential bias, I encouraged colleagues in my PLC to act as what Punch and Oancea (2014) refer to as "critical friends" that served to "cross-check for possible subjectivity, bias, or vested interest" (p. 50).

Instructional structures. A critical component in defining this study as a qualitative case study was my teaching practice. The instructional interventions that bounded the case being investigated in this study included specific lessons, scaffolds, and protocols that evolved as I analyzed data and reflected upon my practice in each phase. The focus of my teaching practice within this case was the effective implementation of instructional structures designed to move students along a continuum of proficiency in the practices of analyzing and interpreting data and of generating arguments using evidence. This six-week unit focused specifically on the scientific inquiry into properties and uses of natural resources. The sequence of the unit was based on a conceptual storyline (Ramsey, 1993) that included lessons based on the instructional sequence for constructing scientific arguments developed by Zembal-Saul, McNeill, and Herschberger (2013).

Lessons designed to increase proficiency in the science practices of interpreting data and generating arguments used throughout this study were based on the continuum presented in the form of a rubric. The lessons and the rubric can be found in the appendix. Instructional structures were used as scaffolds that supported students as they progressed along the continuum. All instructional interventions were measured against the social constructivist theoretical framework that guided the entire dissertation in practice. A collection of scaffolds served to support my students and myself in engaging in practices that we were unable to successfully perform independently (Bransford, Brown, & Cocking, 2000). The primary instructional structure used to scaffold student proficiency in using evidence to generate arguments was a version of the Claim Evidence Reasoning (CER) framework described by Zembal-Saul, McNeill, and Herschberger (2013). The variations in Zembal-Saul, McNeill, and Herschberger's CER explanation framework guided the progression of lessons focused on generating arguments based on evidence.

Additional instructional methods were used to scaffold student proficiency in the lessons of this study based on visible thinking strategies. The tools for academic conversations presented by Zwiers and Hamerla (2017) were employed to encourage students to make their thinking visible through conversation. Protocols were developed to increase student agency in student-to-student dialogue and refine the community of practice. Visual concept maps and charts also served to make thinking visible. A modified form of Calkins' (1983) workshop model was employed to provide students with an opportunity to confirm or revise their thinking through conversation. Additionally, different student grouping strategies, such as small groups, partners, and the whole group, were used throughout the lessons. This study explored how my students and I engaged with these structures and routines within my classroom to support scientific practices based on the definitions by the National Research Council (2012) and the South Carolina Science and Engineering Practices (2014).

Data Collection and Analysis Methods

The purpose of the data collection methods of this study was to explore how participants interacted with and experienced the specific scientific practice of generating arguments using evidence from analyzed and interpreted data. I intended to understand how to maintain the level of scientific inquiry throughout a unit. Data collection and analysis occurred continuously across four phases of this study to develop and refine the instructional tools that increased the use of the specific scientific practices that were missing from the inquiry process within my classroom. Stake (1995), Merriam and Tisdell (2016) argued that the research process of a qualitative case study used interpretation as the primary method of understanding and was therefore inductive and flexible. I revised the context of the study and modified instructional methods as data was collected and analyzed within each phase.

The most appropriate data sources and methods, according to Stake (1995), Merriam and Tisdell (2016), were those that gave the researcher the opportunity to explore the multiple realities and perspectives surrounding the case. Abramson (1992) argued data collected through qualitative methods documented the infrequent and non-obvious transactions often missed with traditional and statistical approaches. The intention of the data collection tools of this study was to portray the varied facets of the phenomenon of scientific practices in a first-grade classroom.

Qualitative case studies typically employed triangulated data from multiple sources (Creswell, 2014; Baxter & Jack, 2008; Merriam & Tisdell. 2016; Patton, 1990; Yin, 2014). The sources allowed for the evolving and unpredictable nature of the phenomenon explored in this study. Qualitative methods predominantly used to obtain multiple perspectives of participants included transcripts, observations, and document reviews (Mertens, 2015). Dana and Yendol-Hoppey (2014) stated it was "important for teacher-researchers to use multiple forms of data as they design their inquiries in order to develop the richest possible picture they can of what is occurring the classroom" (p. 127). Stringer (2007) argued for using multiple methods to collect data because it increased the credibility of data. According to Mertler (2014) quantitative data did not begin to compare to the depth of data collected through qualitative methods.

The data collection methods and analysis of this study were conducted simultaneously during each phase of this study. A review of all data analyzed across each phase was completed at the conclusion of the study to determine an action plan for future teaching and learning practices within my classroom. Table 3.1 provides a schedule for each phase of this case study. A description of data collection and analysis methods is described following the schedule detailed in Table 3.1.

Performance assessment. Data collected from a performance assessment recorded in the first stage and each subsequent phase provided the student perspective on the experiences and impact of the instructional structures of this study. The performance assessment in each phase was used to describe the level of student proficiently in the ability to construct scientific arguments based on evidence. I adjusted or revised the lessons for Phase 2 through four based on the results of the previous performance assessment.

Each performance assessment was evaluated by the rubric found in Appendix D based on the continuum of expectations defined by the South Carolina Science and Engineering Practices (2014) and the CER rubric developed by McNeill and Krajcik (2012). The performance assessment assessed student ability to use analyzed and interpreted data to generate arguments from evidence. The rubric provided a scale ranging from developing to exemplary to determine the level of student performance concerning first-grade expectations. I employed content analysis to analyze the data collected based on the scale found in the Appendix.

The patterns and themes identified within each performance assessment guided the development of the subsequent phase of the study. The three key processes in teaching and learning defined by Ramaprasad (1983) led decisions regarding adjustments necessary for the next phase in the study. The questions asked based on Ramaprasad's guide were:

1. Where are the learners in their learning?
2. Where are they going?
3. What needs to be done to get there?

Table 3.1

Data Collection Timeline

Phase and Timeline	Instructional Intervention	Data Collection Methods	Data Analysis Methods
Phase 1 Time: 1 week Performance Assessment on day 4	None (Baseline)	• Observation • Field Notes • Performance Assessment • Artifacts - Lesson Plan & Student Work	Content Analysis of observation and field notes through deductive coding.
Phase 2 Time: 1 week Performance Assessment on day 4	Intervention 1 (Based on data analysis from Phase 1)	• Observation • Field Notes • Performance Assessment • Artifacts - Lesson Plan & Student Work	Content Analysis of observation and field notes through deductive coding.
Phase 3 Time: 1 week Performance Assessment on day 4	Intervention 2 (Based on data analysis from Phase 2)	• Observation • Lesson Plan • Field Notes • Performance Assessment • Artifacts - Lesson Plan & Student Work	Content Analysis of observation and field notes through deductive and inductive coding. Content Analysis across Phase 1–3 data sources to find larger themes, patterns and categories. Codes quantified to find frequency of theme or code occurrences.
Phase 4 Time: 1 week Performance Assessment on day 4	Intervention 3 (Based on data analysis from Phase 3)	• Observation • Field Notes • Performance Assessment • Artifacts - Lesson Plan & Student Work	Content Analysis and coding across Phase 1–4 data sources to find larger themes, patterns, and categories. Codes quantified to find frequency of theme or cod occurrences.
Final Data Analysis	None (Post-Instruction)		Second Cycle of coding data across phases to reduce codes and themes. Codes and categories linked by weaving codes, themes into narrative form.

Classroom observations. Classroom observations conducted by the educators within my PLC gave the professional perspectives of the experiences and impact of the instructional structures and scientific practices within each lesson. Each lesson within the study was recorded as classroom observation data. The Dissertation in Practice (DP) began with the observation that students in my classroom demonstrated success during inquiry lessons that involved curiosity, questioning, and the related investigations of scientific concepts. A problem of practice occurred when students were encouraged to revise understandings and construct explanations or arguments using evidence. The classroom observations were conducted to identify the specific behaviors and interactions my students and I exhibited during a lesson designed to encourage students to analyze and interpret data to generate an argument using evidence from the observations or data collected.

The classroom lessons in each phase following the initial performance assessment were recorded. The recorded videos were analyzed by the members of my PLC and myself using the EQUIP protocol developed by Marshall, Horton, and White (2009). The EQUIP rubric was used as a tool to focus the unstructured data provided by the observation. Transcripts of PLC observations and discussions were recorded. In Vivo Coding and Process coding was used to create an analytic memo. Saldana (2015) described memo writing as a written reflection of what the data represented because the researcher noted the deeper and more complex meanings it evoked. Codeweaving was used to integrate keywords and codes together into the analytic memo. Saldana's codeweaving process was implemented by putting primary codes, concepts, and themes from the analysis into a small number of sentences. Suggested causation and possible relationships between statements or actions were noted, and a summary statement was written (Saldana, 2015).

A transcript of student and teacher dialogue in each lesson was entered into a Microsoft Excel spreadsheet. Each statement was initially coded through Provisional Coding based on the elements of the CER rubric developed by McNeill and Krajcik (2012). The deductive form of provisional coding was used to investigate the link between the dialogue of the students and teacher during classroom lessons and the scientific practices explored in this study (Dey, 1993; Miles & Huberman, 1994). Codes were inductively developed at the conclusion of Phases 3 and 4 as new categories and themes emerged in the data (Saldana, 2015). All categories identified through analysis of the classroom observation that were not relevant to the research question were dismissed (Lincoln & Guba, 1985).

The analysis of observations conducted in Phase 1 was used as baseline data. At the end of each phase, the patterns and themes identified during the observation analysis determined how to adjust and refine instruction and the development of the lesson plans for the following phase. Codes were quantified to find the frequency of occurrences at the conclusion of Phase 3 and Phase 4 of the study. Determining the percentage or frequency of events, responses, themes, or categories was a process used to verify that patterns existed (LeCompte & Schensul, 2013). All codes created during observations were recorded and stored on Google Drive for subsequent analysis.

Field notes. Field notes recorded in a teacher-reflection journal provided my perspective of the experiences and impacts of the instructional structures and strategies employed to increase student proficiency in the scientific practices explored in this study.

The journal recorded reflections during the planning of each phase in the study, which included the development of the instructional strategies and lesson plan based on data analysis. I also recorded student dialogue, interactions and behaviors observed within the instructional period bounded by this case each day. Merriam and Tisdell (2016) stressed critical thinking as a critical element of reflection and observation notes. At the conclusion of the lesson, I wrote my reflections and experiences with the lesson, including the synchronous moments of contingency. Black and Wiliam (2009) stated simultaneous moments of contingency occur when the teacher makes adjustments in instruction as students share questions and discoveries during the lesson. These moments were critical to understanding how my students and I constructed the inquiry experience within the lesson.

Field notes were analyzed as patterns were observed and sorted into trends. Content analysis was used to analyze the unstructured data provided by these notes. Content analysis allowed me to organize the unstructured data of my notes to analyze any meanings, symbolic qualities, or themes they evoked (Krippendorff, 2013). Initially, In Vivo Coding was used to highlight anything relevant or useful such as repeated words or phrases, specific experiences with science practices and other key terms in the notes that noted common or unique perspectives of the participant-researcher (Saldana, 2015). As the study continued, the codes determined through this type of inductive coding narrowed as common categories were found. It was vital for me to remain aware of potential biases in my observations and analysis. Analytic memos were created using codes and reflections of each field note. To address the issue of bias, I shared my journal with colleagues within my PLC to critically discuss my observations and reflections. Saldana's codeweaving process was employed to summarize the field notes using the most common codes and concepts in a memo.

In addition to a teacher-reflection journal, field notes and memos served as an audit trail. The audit trail provided details on how data was collected within each phase of the study, the categories derived through data analysis, and how planning and instructional decisions were made based on that analysis (Merriam, 2009). The field notes and memos were dated and recorded in a Rocketbook and stored on Google Drive.

Artifacts. Documents in case study research confirm or evaluate other sources, and provide information about events that are unobservable (Stake, 1995). Students assembled a portfolio of learning throughout the six-week unit of inquiry. This portfolio included a collection of student-created and chosen artifacts. Students chose four pieces created throughout the unit of inquiry to include in their portfolio. The first guideline for selecting artifacts was that the documents must be student-created during the unit. The second guideline was that the pieces chosen reflected student learning and growth based on the specific scientific practices. The portfolios provided data on the impact of structure instructional practices on student learning and growth.

I analyzed the artifacts to ascertain levels of proficiency of the scientific practices of analyzing and interpreting data and generating arguments based on evidence. Artifact samples were analyzed using the rubric found in Appendix D based on the continuum of expectations defined by the South Carolina Science and Engineering Practices (2014) and the CER rubric developed by McNeill and Krajcik (2012). Artifacts were also sorted to identify trends of inquiry-based behaviors to explore the impact of the inquiry instruction structures on student learning. Student work was used to confirm or contradict themes and patterns identified through other forms of data. Additionally, the student work was another formative assessment tool in the adjustments from phase to phase within the study.

Teacher produced lesson plans were also collected and analyzed within each phase. The analysis of classroom observation, student and teacher reflections and performance assessments determined the lesson plan of the subsequent phase. As Merriam and Tisdell (2016) suggested, data analysis became more intensive as the study progressed. The lesson plan served as both a record of classroom experiences and a reflection of the progression of the study. The lesson plan was compared to the data collected by the observation of the lesson to determine how the plan and the enactment of that plan were similar and different. This process gave insight into how the interactions between the teacher and her students impacted learning and the performance of science practices. At the conclusion of the study the lesson plans were compared to identify themes of change and instructional methods.

Holistic data analysis. At the conclusion of the final phase, the data collected throughout the study were combined and consolidated to observe participant behaviors as they engaged with various instructional strategies. In this case study, a convergence of the data provided a holistic understanding of the case (Yin, 2014). The convergence process strengthened the findings found from multiple data sources (Baxter and Jack, 2008). It was vital to bring order and meaning to the qualitative data collected throughout the study to uncover what was below the surface (Hubbard and Power, 2003). Convergence of all data ensured a complete interpretation of the inquiry-based experiences in my classroom to determine how a focus on specific science practices maintained the level of scientific inquiry.

At the conclusion of the four-phase case study, transcripts of classroom lessons, memos from field notes and lesson observations conducted by my Professional Learning Community, performance assessment rubrics, and student artifacts were compared to identify any common or varied experiences. The second cycle of coding was conducted across all transcripts and memos to reduce, consolidate, and connect codes. The frequency of codes and categories were linked through the codeweaving process to integrate the analysis of the qualitative data into narrative form. Thematic analysis identified patterns and reduced categories into broad themes within the context of each research question (Braun & Clarke, 2006).

The data in narrative form was further analyzed to create an action plan to maintain inquiry throughout subsequent units with the students in my classroom, included in Chapter Five. The purpose of my action research study was to effect positive change within my local classroom, not to draw conclusions about all first-grade classrooms based the student-participants as a sample of the broader population. As Pathak (2008) stated, “no inferences have to be drawn about the population from the study of sample, so inferential statistics do not come into the picture” (p. 16).

Validity and Transferability

The validity and transferability of this study was considered through each stage in the action research process. Merriam and Tisdell (2016) created a framework to ensure the validity and transferability of the methods in qualitative interpretive research. Triangulation was the primary strategy implemented to establish internal validity. This study employed multiple sources and methods of data to verify and support findings. Inferences from data collected from field notes were confirmed or eliminated as it compared to data from performance assessments, documents or artifacts, and classroom observations. Performance assessments and artifacts provided student perspective, classroom observations presented peer perspective, and field notes offered my perspective of the impact of instructional strategies and structures focused on increasing student ability to analyze data and generate arguments. Peer-debriefing was the method of investigator triangulation to ensure researcher interpretations remained focused on the research question. Patton (2015) argued that triangulation in any form increases the credibility of a study.

The members of my PLC also increased the internal validity through respondent validation. I solicited feedback from my peers in the PLC on my emergent or preliminary findings (Merriam & Tisdell, 2016). Maxwell (2013) claimed respondent validation was the most crucial strategy for researchers to employ to identify misinterpretations and biases throughout the study, thereby increasing internal validity. Respondent validation occurred with the PLC during our weekly meetings, each week during the study.

By definition, the replication of an interpretive qualitative case study never yields the same results (Merriam & Tisdell, 2016). The reliability of this case study was evaluated by the degree by which the results were consistent with the data (Merriam and Tisdell, 2016). An audit trail increased the reliability. The audit trail described how the data was collected, how codes and patterns were determined, and how decisions were made within the case (Merriam & Tisdell, 2016). Researcher reflections, decisions, and questions were collected and recorded.

The steps taken to increase internal validity and reliability strengthened the external validity or transferability of this study (Merriam & Tisdell, 2016). However, case study research has often been criticized for its lack of generalizability (Denzin & Lincoln, 2000). Lincoln and Guba (1984) suggested the focus of transferability for a qualitative study lied more with the site of the application of transfer than with the original case. To increase the possibility of transferability, the methods provided detailed and descriptive data (Lincoln and Guba, 1994; Seale, 1999). Thick descriptions of the context and inferences of this study allowed readers to determine the significance of the meanings regarding their contexts. These descriptions increased the transferability of the study.

Ethical Considerations

Mertler (2014) stated the critical ethical principles to consider when planning and conducting action research were beneficence, importance, honesty, confidentiality, and anonymity. The purpose of this action research study was one of beneficence and significance. It served to acquire knowledge about the educational process to address the first-grade students at the study site better. The potential findings of this research were relevant to the field of inquiry-based instruction within IB PYP units of inquiry. As the teacher-researcher, I gained valuable insight into my practices to determine future steps in increasing scientific practice and inquiry-based instructional methods within my classroom.

Principle of honesty. Mertler (2014) regarded honesty as “absolutely essential when conducting research” (p.112). The teacher researcher remained committed to honest communication with student participants throughout the action research study to create an authentic environment of inquiry. All participants were honestly informed as to how, why, and what data would be collected. An informed consent form relating the nature of the study was given to each student participant, giving students and parents full disclosure of the research study. The parental consent letter (See Appendix A) included a guarantee of confidentiality and anonymity, information on the methods of data collection, and availability of the summary of findings (Mertler, 2014).

As the teacher researcher, I honestly communicated with the school district and study site administration before initiating the action research study and throughout the completion of the study. A research proposal (See Appendix B) was submitted to the Director of Research, Evaluation, and Accountability for the school district in Fall 2017. The study complied with research guidelines established by the district Accountability and Quality Assurance as outlined in the research proposal (Greenville County School District [GCSD], 2016). The administration was offered full disclosure of all elements of the case study, methodology, and analysis. Upon conclusion of the study, a full report was submitted to the Director of Research, Evaluation, and Accountability as stated in the District Research Guidelines (GCSD, 2016).

Principle of confidentiality and anonymity. Accurate data collected from students allowed participants to remain anonymous and their responses to be kept confidential. Student participants remained anonymous in classroom transcripts, field notes, and analytic memos. Students without informed consent from a parent or guardian did participate in the inquiry-based instruction but were not included in the lesson transcripts or videos each week.

Developing an Action Plan and Reflecting

These two stages of the action research process, developing an action research plan and reflecting, coincided. They were both at the heart of my purpose. The act of reflecting upon the data collected and the development of an action plan continued the subsequent cycles of action within my classroom and were critical to my professional development (Mertler, 2014). When I reflected on what I learned and determined what to do, I created change that improved participant educational practices (Carr & Kemmis, 1986).

The development of an action plan meant I would be changing instructional practices in the future (Mertler, 2014, p. 211). The element of meaningful learning that took place through professional reflection was of particular importance in the stage of action planning because it was critical to creating a plan of action that changed elements of our classroom for the better. The understanding I gained through reflection and analysis of data led to the formulation of a plan for change and even a new problem for future action research, which continued the cycle.

Bryant (1996) suggested the act of reflection during action research was not aimless and abstract thinking because it demanded intentional action within the situation. Mertler (2014) described two fundamental ways to engage in deliberate reflection. Reflection of intended as well as unintended outcomes of a study strengthened the validity of data analysis and conclusions, as well as positively impacted subsequent action research cycles for teacher-researchers (Mertler, 2014).

Conclusion

This study was designed to meet the characteristics of action research described at the beginning of this chapter. The research question guided the process by exploring a practice unexamined within literature related to inquiry-based practices. The social constructivist perspective of this research plan placed the teacher-researcher and research participants in the role of knowledge creator as opposed to the researcher as the consumer of knowledge transmitted by outside experts (Anderson, Herr, & Nihlen 2007; Hubbard & Power 2003; Reason & Bradbury, 2008). This examination of teaching and learning practices within the particular context of my classroom and students explored a problem of practice that reflected the unique needs and interests of all participants (Stringer, 2007).

Chapter 4:

Findings

Introduction

The qualitative case study design provided an opportunity to explore how a focus on the scientific practices of interpreting data and generating arguments based on evidence impacted scientific inquiry in a first-grade classroom. The study was guided by two research questions:

1. How do students develop proficiency in generating an argument from analyzed and interpreted data in a first grade classroom?
2. How does a focus on specific science practices maintain the level of science inquiry in a 1st grade classroom?

Students participated in eight lessons divided into four phases. At the end of each phase students were administered a performance assessment. Student proficiency demonstrated on each assessment was determined using a rubric based on the continuum of expectations defined by the South Carolina Science and Engineering Practices (2014) and the Claims Evidence Reasoning (CER) rubric developed by McNeill and Krajcik (2012). At the end of each phase I reflected on these results, along with the behaviors and statements that occurred during each lesson to adjust or revise instructional interventions in each subsequent phase. Interventions were designed to increase student proficiency in generating scientific arguments using analyzed and interpreted data. This chapter presented the findings from the content analysis of the data collected as it related to the problem of practice and research questions of this study.

Seventeen students within one first grade classroom participated in the lessons, created artifacts, and completed performance assessments in each phase of the study. The discourse that occurred between the teacher and student-participants within each lesson during the study was transcribed, coded, and analyzed. The students were numbered randomly to remain anonymous throughout data collection and analysis during this study. Demographics of the student-participants are presented in Table 4.1.

As described in the previous chapter, transcribed lessons were coded deductively during the first cycle of analysis using provisional codes based on the CER rubric developed by McNeill and Krajcik (2012). Additional codes were developed inductively through descriptive coding. This data was triangulated with codes developed from the analysis of notes taken during lesson observations conducted by my professional learning community (PLC) and reflections recorded in my teacher-researcher fields notes. As codes were analyzed and revised through multiple cycles of analysis throughout the study, themes began to surface. Thematic analysis within the constructivist framework generated themes related to the structural and instructional conditions that produced individual behaviors and dialogue within the case (Braun & Clarke, 2006).

This chapter presented the major themes that emerged in relation to each research question. The presentation of results that followed included a narrative description of each theme and a discussion of how the data collected through classroom transcripts, observations, and field notes related to the theme described and connected to other themes presented. Data excerpts and other related evidence were included to support the findings. A summary of the entire thematic analysis concluded the chapter.

Table 4.1

Demographic Characteristics of Sample Based on Parent/Guardian-Generated Survey

	Overall	**Percentage**
Total	**17**	**100%**
Gender		
Cisgender male	**7**	**41%**
Cisgender female	**10**	**59%**
Race/Ethnicity		
Caucasian	**11**	**64%**
Hispanic	**3**	**18%**
African American	**3**	**18%**
Language Status		
Non-English Language Learner	**15**	**88%**
English Language Learner	**2**	**12%**
Socio-Economic Status		
Free/Reduced Lunch	**6**	**35%**
Non-Free/Reduced Lunch	**11**	**65%**

Table 4.2

Performance Assessment Rubric

Performance Assessment Rubric					
	0 Does not meet	**1 Developing**	**2 Approaching**	**3 Proficient**	**4 Exemplary**
Claim	Does not make a claim.	Makes an inaccurate claim	Makes an accurate but vague claim.	Makes an accurate claim.	Makes an accurate and complete claim.
Evidence	Does not provide evidence.	Provides vague evidence or evidence that is not provided by the data.	Provides 1 piece of evidence from the data that logically supports the claim	Provides 2 pieces of evidence from the data that logically supports the claim	Provides more than two pieces of evidence from the data that logically supports the claim
Interpreting Data	Records but does not interpret data.	Organizes or describes the data collected but does not recognize patterns or relationships.	Describes patterns or relationships but interpretations are not logical or directly related to the data.	Student interprets data to describe logical patterns, relationships, and/or predictions that support arguments or claims.	Student interprets data to construct meaning and describe logical patterns, relationships, and/or predictions. Interpretations support arguments or claims.
Reasoning	Does not provide reasoning			Connects the evidence to the claim with an explanation.	Connects the evidence to the claim with an explanation by using a scientific principle.

First Grader Proficiency in Scientific Practices

The first research question explored how students developed a proficiency in generating an argument from evidence in a first grade classroom. To determine student proficiency, four performance assessments were administered in each phase of the study. The assessments were scored using a rubric based on the continuum of expectations defined by the South Carolina Science and Engineering Practices (2014) and the CER rubric developed by McNeill and Krajcik (2012). The rubric, in Table 4.2, established how students were expected to demonstrate scientific practices on a proficient or exemplary level.

Table 4.3

Multi-Phase Performance Assessment Results

	Percentage of Students Demonstrating Proficient or Exemplary Level (as determined by the Performance Assessment Rubric in Table 4.2)				
	Pre-Assessment	Phase 1	Phase 2	Phase 3	Final
Claim	0%	41%	65%	69%	100%
Evidence	0%	53%	53%	56%	94%
Interpreting Data	0%	35%	71%	75%	94%
Reasoning	0%	0%	6%	6%	88%

Results provided evidence of an increasing level of proficiency in the scientific practices assessed throughout the study. At the conclusion of the study every student was able to independently analyze and interpret data to generate a claim with supporting evidence on the proficient or exemplary level on the final performance assessment, and 88% of students were able to provide scientific reasoning to support their claim on the proficient or exemplary level. The data provided from these performance assessments validated the analysis of lesson transcripts, field notes, and lesson observations presented in this chapter to answer the research questions of this study.

Table 4.4

Content Analysis Themes and Subthemes for Research Question 1

How do students develop a proficiency in generating an argument from evidence?		
Final Cycle Codes/Categories	**Subthemes**	**Themes**
Student to Student Dialogue Building/Elaborating on Ideas	Shared Understanding	**Engaging in academic conversations**
Teacher to Student Prompts Student to Student Prompts	Questioning	
Sentence Stems Academic Vocabulary Conversation Protocol	Conversation Scaffolds	
Resistance Lack of Engagement No response	Avoiding Risks	**Taking risks**
Student Voice Argumentation Partners	Encouraging/ Supporting Risks	
Visible Thinking Guiding Questions	Critical Thinking Scaffolds	**Interacting along a continuum of support that scaffolds learning**
Personal Connections Link to Previous Learning/Knowledge	Student-Centered	
Reflection Decision Prompts Peer Support	Transfer Responsibility of Learning	

Codes and categories were reorganized and synthesized with each cycle of content analysis. Final cycle codes and categories were clustered into broader subthemes and themes. Thematic analysis of the data identified three key elements that reflected how students increased proficiency in generating arguments from data. These themes were categorized as: engaging in academic conversations, taking risks, and interacting along a continuum of support that scaffolds learning.

The process of clustering codes to determine the main themes related to the first research question of this study can be found in Table 4.4. The remainder of this section provides greater description of how these themes answered the question: How do students develop a proficiency in generating an argument from evidence?

Engage in Academic Conversations

Content analysis of lesson transcripts, teacher-researcher field notes, and PLC observations conducted at the end of each phase of the study found an increase in student engagement in academic conversation impacted student proficiency in generating an argument from evidence in my first grade classroom. This was the most significant theme to emerge from the study. All instructional or discourse factors impacting student argumentation and analysis or interpretation of data were related to this theme.

Initial findings. Prior to this study student participants were unable to analyze and interpret data, as seen in the results from the first performance assessment administered. An analysis of the first three transcribed lessons demonstrated a significant amount of student discourse in relation to teacher talk. Descriptive coding of the transcripts identified the majority of student conversation centered on the content or data collected from experiments and observations. Despite the amount of discourse related to data, very few statements included any reference that the students were analyzing or interpreting the data. During lesson one 12% of student statements were coded as analyzing and interpreting data. In Lesson Two student comments related to data included, “I saw a rock the other day that had lots of sparkly stuff,” and “Look at water.” My PLC commented during their observation of lesson two that students often described the data, but they did not make an effort to interpret how the data could serve as evidence to support a claim. In my field notes I reflected that students seemed to make comments about data based on what they hoped I wanted to hear. According to my notes, students made no effort to find patterns or answer questions about the data. The presence of student dialogue did not ensure students were analyzing or interpreting data to generate scientific claims.

Content analysis of student dialogue also exposed a lack of academic vocabulary, shown in Table 4.6. On the first performance assessment a student stated, “Natural resources are data.” Another student wrote, “I think there is data in the squares,” as her scientific argument. When students were prompted to share what they learned from the data, they often struggled to articulate their ideas. Lesson observations conducted by the PLC supported the content analysis of transcripts. The PLC noted that students appeared to resist analyzing data or making scientific arguments out of a lack of confidence in the appropriate use of scientific vocabulary.

Teacher prompting primarily guided the process of creating a shared understanding of data and content during the first three lessons of the study. In Lesson

Two students demonstrated their inability to generate shared understanding of the data due to parallel talk.

> Teacher: What evidence supports your argument that a cactus needs water?
>
> Student 1: It holds water.
>
> Student 6: Birds can drink water from them.
>
> Student 5: It has roots.
>
> Student 2: It also has waxy stems.
>
> Teacher: So how does that evidence tell me that a cactus needs water? Can a cactus hold water but not need it to live? I can have a cell phone in my pocket, but I don't need it to live.
>
> Student 2: The waxy stems hold the water in.
>
> Student 5: But it sucks up the water by the roots.
>
> Teacher: And what does it do with that water?
>
> Student 6: It needs the water because it uses it to help it stay alive and grow.
>
> Student 1: Yeah, remember that picture of how the cactus uses the water? Just like our seeds would not grow without water.

Every question that prompted students to elaborate on ideas in the first two lessons was asked by the teacher, as demonstrated in Table 4.8. Transcripts indicated that student talk dominated lessons one and two, yet very few student statements built or expanded upon a previous thought or statement. Students were not engaged in a significant amount of two-way conversation with peers.

PLC classroom observations noted students were enthusiastic as they collected data, but were significantly less engaged in the process of analyzing or interpreting that data. Behaviors observed during video observations that demonstrated student avoidance in any type of dialogue that asking students to think critically were coded as resistance. In the video observations of the first few lessons conducted by my PLC, four students did not interact in any student-to-student conversation and twelve out of seventeen students were coded as demonstrating resistance to critical thinking at some point during a lesson.

Academic conversation instructional interventions. The intervention implemented in response to the initial analysis of student dialogue transcribed from the first three lessons was to support and scaffold academic conversation. The first strategy employed was to establish a common language for scientific practice that would be used by the teacher and students. Academic vocabulary was introduced within a community of practice, as described in Lave and Wagner's (1991) description of situated learning. As students discussed data or generated arguments in student-led conversations during the lesson, I verbally labeled the comments with related academic language such as, "You told your group something you noticed in the data." When a student made a claim based on evidence, I would state, "That was a claim that answered your question. The evidence you used to support your claim came from the data you collected." At the end of a lesson the students would share and reflect. During this time students would be asked to reflect on the evidence they found, or what they learned from the data.

Additionally, sentence stems were introduced to support academic conversation between students. Sentence stems such as "My claim is…" and "The data tells me…" were provided to give students support as they shared how they used scientific practices. Students practiced using these sentence stems in role-playing situations that occurred throughout the school day, apart from the lessons. The sentence stems were written on table cards for students to use as a reference during the lessons as they worked in small groups or with partners.

Findings from initial academic conversation interventions. Content analysis of student-to-student dialogue was conducted at the end of the second and third phase of the study. The frequency of statements that reflected an element of scientific practice in lessons increased from 41% of student statements at the beginning of the second phase to 85% of student statements at the end of the third phase. In the second phase only one student made a statement related to scientific reasoning, "Rocks are nonliving because they do not need water. Living things need water to live" Content analysis of the two lessons in the third phase identified and coded nine statements as scientific reasoning.

Students increased their ability to analyze and interpret data, but as a whole students were not providing two or more pieces of evidence to support each claim. The average pieces of evidence used by students to support each claim generated in the fifth lesson was 1.4. In the sixth lesson students provided 1.85 pieces of evidence to support each claim, as shown in Table 4.5.

Table 4.5

Average Number of Pieces of Evidence used to Support a Claim During a Lesson.

Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
0.55	0.7	0.75	0.69	1.4	1.85

Content analysis of lesson transcripts and teacher field notes found students increased the use of sentence stems as they shared ideas with the teacher or with their peers. Students were using these sentence stems to make claims during the lesson based on data analysis and other evidence. The percentage of statements that included the words data, claim, evidence, or reasoning in student-to-student or student-to-teacher dialogue is shown in Table 4.6.

Table 4.6

Percentage of Statements including Vocabulary Words: Claim, Evidence, Data, Reasoning

Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
3%	18%	8%	4%	50%	74%

During the fifth lesson 50% of student statements included a form of academic vocabulary related to generating arguments from data. In the sixth lesson 74% of student statements included the words data, claim, evidence, or reasoning. After observing and collecting data about a rock during Lesson Six, a group of three students collectively generated this statement:

> Our claim is this rock is made by magma. Our evidence is it is black, it has lines, and it looks like it cooled. The reason we think this is an igneous rock is because it looks like it was cooled magma.

Another example of students using academic vocabulary to generate an argument was found in this statement:

> The claim is it is a sedimentary rock. Our evidence is it has stripes. Our reasoning is that it looks like it was formed by sand & plants pushed together and it smells like plastic.

Many students who did not interact in conversation during lessons in the first phase were increasingly participating in conversation with each subsequent phase.

Students appeared to focus primarily on their own individual ideas through parallel talk, as opposed to interacting in an interchange of ideas through academic discourse. Only two students asked a question to prompt another student to explain or expand upon their thinking throughout Phase 2 and Phase 3 of this study. The frequency of student-to-student prompting in the second and third phase of the study verified the observations noted in my teacher field notes and PLC notes. The PLC noted that there was very little evidence of students building on each other's ideas through conversation during lessons that occurred in Phase 2 and 3. In my teacher field notes I wrote:

> Students seem to rely on my prompting out of habit. I need to find a way to create new habits for how to share and defend scientific arguments or how to talk about their interpretations of the data.

Conversation protocol intervention. Following the analysis of Phase 2 and Phase 3, a set of conversation expectations were introduced to the student-participants. The intention was to create an environment in which student talk was a purposeful process of meaning making, in which all parties were sharing, responding to, and expanding upon ideas. The first intervention was to develop a set of conversation norms. Students brainstormed what conversation would look and sound like if everyone was sharing, learning, and generating ideas together. I introduced Zeiers, O'Hara and Prichard's (2014) description of constructive conversation, "back-and-forth talk that builds ideas and accomplishes a useful learning purpose" (p. 187). In small groups students watched video clips of small group conversations from previous lessons and collected data by looking for examples and non-examples of constructive conversation that involved students interacting and exchanging ideas. The students brainstormed a list of conversation norms based on their observations.

The norms included:

1. Look and listen to who is speaking
2. Everyone shares and responds
3. Be respectful when you don't agree.

After clear expectations for academic talk were established, a constructive conversation protocol was developed based on Zeiers, O'Hara and Prichard's (2014) description. I modeled the protocol, and then students practiced and modeled the protocol with their peers. The protocol included the following steps:

1. Share
2. Ask for More
3. Explain
4. Build On or Challenge

The first step in the protocol was Share. A student shared a claim or analysis with the partner or group. Then, the partner or group would complete step two: Ask for more. Students had two prompting questions to choose from during this step. Why do you think that? What is your evidence? Then, the partner who shared first explained or elaborated upon the original statement in step three. In the final step of the protocol the partner, or each group member, built on the ideas of the student with a connection using the sentence stems, "I agree, because I know that…" or "This also could mean…" The partner or group member could also challenge the student's ideas by stating, "I disagree because…" Students practiced the constructive protocol of Share-Ask-Explain-Build or Challenge in partnerships during lessons in science and in other subjects throughout the day to increase their proficiency.

Findings of final phase. A higher frequency of statements containing a scientific claim, relevant evidence, or scientific reasoning was found in each lesson conducted in the final phase of the study than in any of the lessons throughout the first three phases. The most significant growth was found in student statements that included scientific reasoning.

Table 4.7

Percentage of Statements Coded as Scientific Reasoning out of Total Student Statements

Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8
0%	5%	3%	0%	15%	10%	20%	20%

When the total number of statements transcribed across the first three phases was combined, 5% were coded as reasoning. In the final two lessons of the final phase 20% of student statements were coded as reasoning. The number of statements indicating students were providing scientific reasoning for their claims increased more than two times between the first three phases and the last phase. Accompanying the increase in student statements reflecting elements of scientific practice was significant growth in student explanation and clarification of thought through dialogue. The following excerpt is one example of two students using the Share-Ask-Explain-Build or Challenge Protocol to explain and clarify their arguments.

Student 3: Plants need clay to survive.

Student 4: What's your evidence? Tell me more.

Student 3: It took a long time for the water to come out of the clay.

Student 4: The water came out of the loam faster.

Student 3: I don't think it's good for water to come out fast. Plants need water to live.

Student 4: Plants need water, but remember they don't need too much water

Student 3: Then maybe the loam is the best because it holds more water than clay but it doesn't hold all the water. The loam didn't let the water go too fast or too slow.

In the final phase of the lesson, student-to-student prompting dominated the flow of academic conversation. During each lesson in the last phase, every student asked at least one question to prompt another student to explain, defend, or expand upon his or her thinking.

Table 4.8

Frequency Percentage of Student-to-Student Questioning out of Total Student Statements

Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8
0%	5%	0%	1%	0%	1%	20%	20%

A connection between the increase in codes identifying student-to-student prompting and codes for scientific reasoning was found through final analysis. During the third cycle of content analysis I observed that every statement that indicated scientific reasoning was made after a statement that was coded as a student-to-student prompt. Teacher-researcher field notes and PLC observations identified student use of the conversation protocol to explain, expand, and challenge claims as having a significant impact on student use of scientific reasoning to explain or defend their arguments based on data. Results from the final performance assessment verified these observations. The percentage of students providing scientific reasoning to support their argument based on data increased by 82% from the first to the final performance assessment, as was shown in Table 4.3.

Taking Risks

Another theme that emerged from data was the contrasting behaviors of taking and avoiding risks. Observations conducted by my PLC noted elements of resistance at the beginning of the study. Students not only avoided participation through discourse in the first set of lessons, many students demonstrated resistant behaviors. These observed behaviors were coded as disengaged or disruptive. Disengaged and disruptive behaviors decreased in frequency with each subsequent lesson. As students increased proficiency in scientific practices throughout the study, a theme of risk-taking emerged. The emergence of this theme led to me to recode disengaged and disruptive behaviors as avoiding risks.

Initial findings. Students demonstrated a lack of engagement and response during the first few lessons. Six students did not participate in student-to-student or student-to-teacher dialogue in either the first or second lesson, even with teacher prompting. Throughout all lessons within the first phase of the study, 12 student behaviors were descriptively coded as disengaged. Disengaged behaviors included rolling on the floor, turning away from the group, and playing with items such as pencils or artifacts. There were a total of six instances within the first phase in which students demonstrated resistance by making jokes, comments, or funny faces unrelated to the data or evidence investigated. I noted in my field-researcher notes that these behaviors appeared to be motivated by the desire to distract others in the group. These behaviors were coded as disruptive.

Other behaviors exhibited during the lessons in the first phase of this study were coded based on the type of engagement and dialogue. Three additional behavior categories emerged through the process of descriptive coding: compliant, constructive, and empowered. Students who demonstrated compliant behavior participated in conversations and the process of analyzing data and generating arguments, however they were not actively constructing meaning independently or with peers. Other students were actively constructing meaning and building on other students' ideas or conclusions. These behaviors were coded as constructive. Occasionally a student was observed taking initiative to analyze data further, taking risks to generate new arguments based on data, or connecting previous knowledge with evidence discovered during the investigation to establish scientific reasoning. These behaviors were coded as empowered. Later in the study constructive and empowered behaviors were identified and relabeled as academic risk taking.

During the first lesson, most student behaviors were coded as compliant, disengaged, or disruptive as shown in Table 4.9. In the second lesson students were given two opposing arguments related to a student-generated question. As students collected and analyzed data to choose their side of the argument, fewer students were disengaged and disruptive than they were in the first lesson. More students were compliant and constructive when motivated to demonstrate how their argument was correct. An example of students demonstrating constructive behaviors was seen in the following excerpt of student dialogue from the second lesson. Students were taking a risk to challenge and change their ideas as they exchanged their evidence and reasoning to support their case that cacti need or do not need water.

Student 1: The cactus has waxy stems so water stays inside the plant when the plant gets hot.

Student 2: Yeah, and the stems are big so water stays inside so it doesn't need any water.

Student 1: Does the plant use the water inside the stems to stay alive? If the cactus didn't have the water inside the stems it would probably die.

Student 2: So it does need water. A cactus does need water to live. I need to change mine.

Teacher field notes highlighted another aspect of resistance that occurred during the first phase of lessons: teacher resistance. The ratio of behaviors that were coded as disruptive or disengaged to the number of behaviors that were labeled as compliant or constructive was 3 to 14. Analysis of my lesson reflections and field notes from the first phase of the study highlighted my disproportionate level of attention given to the small number of disruptive and disengaged behaviors during and after the lesson in contrast to the level of attention I gave to compliant and constructive behaviors. Upon personal and collaborative reflection with my PLC, a personal fear emerged. The fear I identified was that students would become even more disruptive and disengaged as I released my control and gave them greater autonomy. I knew instructional decisions that would potentially increase student agency required me to take a risk by reducing my hyper focus on student disruption or lack of engagement and increasing my focus on supporting my students in the process of analyzing data and constructing meaning.

One trend stood out during content analysis at the end of Phase 1. In instances when students were given the opportunity to take different sides of an argument as in the excerpt above, they were more willing to share and support their position using evidence with a partner. Teacher-researcher field notes and PLC observations of the first few lessons highlighted a contrast in risk taking between students with different levels of social or academic capital. As a result, I separated statements of students with free or reduced lunch from those without free and reduced lunch in a new Excel spreadsheet. Then I did the same process for race or ethnicity, English Language Learners (ELL) or non-ELL and biological gender. I planned to observe and compare the findings of each phase of the whole to those same findings in these isolated demographic categories to identify any patterns or differences in risk taking among these groups. The new discoveries and questions raised by these initial findings were the catalyst for instructional strategies implemented in each of the following phases. I wanted to explore what elements of argumentation increased student and teacher risk taking.

Instructional interventions. Based on the finding that students appeared to take more risks to engage and share their thinking with others when they were given the opportunity to take sides and defend an argument, I established argument partners. I clearly stated and modeled the purpose and expectations of these partnerships for the students previous to putting them into practice. Students understood the purpose of argument partners was to defend your claim to your partner with clear and sufficient evidence. Students were expected to take turns, be prepared, disagree respectfully, and be kind. In the final three phases of the study, students analyzed and interpreted data in small groups, then met with an argument partner to state their claim and supporting evidence. A range of strategies that included student-chosen, teacher-chosen based on student-generated arguments, and teacher-chosen based on other heterogeneous factors formed the partnerships.

The Constructive Conversation Protocol described in the previous section to strengthen student-to-student academic dialogue was also implemented to increase student and teacher risking taking. The desire was to provide a structure to support students in demonstrating more empowered behaviors than compliant ones. The protocol established acts of creating, adjusting, and expanding upon ideas and arguments as the standard practice of student-to-student dialogue. The specific structure of the Constructive Conversation Protocol included student-to-student prompting to release the role of conversation leader from the teacher to the students.

Table 4.9

Observed academic behaviors at three points during a lesson

	Phase 1	Phase 2	Phase 3	Phase 4
Risk-Avoiding Behaviors	**80**	**74**	**47**	**6**
Disengaged	12	7	2	0
Disruptive	6	2	0	0
Compliant	62	65	45	6
Risk-Taking Behaviors	**22**	**28**	**49**	**96**
Constructive	22	26	40	62
Empowered	0	2	9	34

Final findings. As the majority of students demonstrated a shift in behaviors from compliant to empowered, the disruptive and disengaged behaviors disappeared completely. In the final phase of the study zero students were coded as demonstrating disengaged or disruptive behaviors in teacher-researcher field notes and in notes taken during PLC observations. Four out of seventeen students in Lesson 7 and two students in Lesson 8 were coded as demonstrating compliant behaviors. All other students demonstrated empowered behaviors. Students were taking risks to explain and defend their ideas and arguments with partners and many students changed their argument when a peer challenged their evidence. Every student who demonstrated disruptive or disengaged behaviors during the first phase demonstrated empowered behaviors during the final phase.

Field notes and PLC notes identified the use of evidence as a critical piece in student avoidance or willingness to generate an argument. Some students easily made claims, which led the PLC team and me to identify them as risk takers in the first few phases. However, those same students struggled to support those claims with evidence in later lessons. Other students appeared to avoid stating claims in the first few lesson, but as they learned the role of evidence they gained confidence in the use of evidence to validate their claim. To investigate this observation further, the average number of statements per student that were coded as a claim with supporting evidence was determined for the whole class and for specific demographic-based subgroups, shown in Table 4.10. The role of evidence in the level of risk students were willing to take to demonstrate scientific practices which was observed by my PLC and myself was verified in the data displayed in Table 4.10.

As Table 4.10 shows, all demographic groups increased the average number of statements containing a claim with evidence over the course of the study. In the first two lessons boys were more willing to state a claim if they had evidence. In the first few lessons girls made a significant number of claims. However, the majority of girls were not able to support their claim with evidence. As students gained proficiency in collecting and analyzing data, the girls became more willing to take the risk to support their argument with evidence. English Language Learners (ELL) avoided opportunities to share a claim with or without evidence in the beginning of the study. In the final two phases of the study ELL students doubled, and sometimes tripled the number of claims with supporting evidence shared during a lesson. The increased focus on academic vocabulary and the introduction of the Constructive Conversation Protocol gave ELL students the support necessary for them to take academic risks.

Table 4.10

Average Number of Statements per Student Coded as Claim and Supporting Evidence

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8
Entire Class	0.17	0.5	0.53	0.4	2.2	1.5	1.29	1.35
Free/Reduced Lunch	0.16	0.67	0.28	0.17	2.2	2.2	1	1
Non-Free/Reduced Lunch	0.22	0.36	0.7	0.6	2.1	1.5	1.6	1.6
English Language Learners	0	0.5	0	1.5	2	1.5	1	1
Non-English Language Learners	0.18	0.5	0.53	0.24	1.7	1.4	1.2	1.2
Female	0	0.33	0.5	0.1	2.9	1.6	1.6	1.4
Male	0.43	0.7	0.57	0.85	1.7	1	1	1.3

An increased focus on student voice was recorded multiple times in notes collected from PLC observations and teacher-research field notes. The PLC commented that the Constructive Conversation Protocol promoted and encouraged student voice, empowering students to adjust and expand their ideas as they interacted with others. Three students, who made very few statements of any kind in the first few lessons, began taking the risk to explain and defend their claims in the last few lessons. All three of these students used evidence to justify their arguments. The evidence served to validate their claim and reduce the risk in sharing it with their peers. These three students always shared when interacting with an argument partner. The norms and expectations of argument partners implied that any argument could be justified with evidence, alleviating the risk of being wrong.

The following excerpt is a conversation between two argument partners during the final lesson. Student 9 was typically a high-achieving, non-free and reduced lunch student who often dominated group discussion. She cried during the first few phases when asked to support her argument or claim with evidence because she was accustomed to getting answers correct without justifying or explaining herself. Student 12 was a female student who qualified for free lunch. She made very few comments of any type during the first few lessons of this study. In my field notes I wrote that this student did not appear confident in her ability to state a claim. Both girls demonstrated engaged, yet compliant behaviors at the beginning of the study. During the final lesson both students demonstrated constructive behaviors as they explained and defended their arguments. Student 12 generated new thinking at the end of their conversation, reflecting more empowered than constructive behaviors.

Student 12: My claim is oak wood is the best to build a house with.

Student 9: What's your evidence?

Student 12: It does not bend and it does not break.

Student 9: My claim was the crepe myrtle is the worst wood to build a house with.

Student 12: What's your evidence?

Student 9: My evidence is it has a check in the bends, breaks, and scratches columns, so it bends, breaks, and scratches easily.

Student 12: Why do you think that is bad for a house?

Student 9: My reasoning is a house needs to have strong wood. If you pick crepe myrtle then it will not be strong and your house will fall down.

Student 12: I agree. I think we have different arguments but we are both right. Houses need wood that is strong. So a house needs the oak wood that won't bend or break. Some of these natural resources are strong and are good for houses and some are not.

Both students in this example were able to defend their argument with evidence. Student 12 was willing to risk sharing her claim before her partner shared because she was confident that her evidence supported her argument. Student 9 was confident that her evidence supported her argument because she analyzed the data she collected as she tested each material. The evidence played a different role for each student, but it allowed both girls to confidently and competently take a risk to demonstrate their proficiency in the scientific practice of generating an argument with supporting evidence.

Interacting Along a Continuum of Support that Scaffolds Learning

The instructional scaffolds implemented throughout this study provided a continuum of support as students increased proficiency in the scientific practices investigated. In the first three phases of the study instructional supports focused on visible thinking tools, guiding questions, and student-centered connections. At the end of each lesson students shared brief reflections on their growth towards generating a claim based on evidence and set personal goals for the following lesson. During the final stage of the study the continuum of support shifted from teacher-guided to student-guided. Students used decision prompts through the Constructive Conversation Protocol to support each other as they generated, adjusted, and expanded on scientific arguments.

Initial findings. As discussed in the two previous sections, student resistance was more evident when critical thinking was required. As demonstrated in Table 4.2, students were not able to analyze and interpret data on the initial performance assessment completed before the first lesson. Content analysis of the first lesson coded 13% of student statements reflected analyzing or interpreting data. Zero statements in the second lesson indicated students were analyzing or interpreting data. Students were very proficient in using prior knowledge and personal connections during the first phase of the study. During the first lesson 43% of student statements were coded as a connection to previous learning or knowledge.

Instructional interventions. Building on the student strength of making connections to prior experience and knowledge, the first instructional intervention was to ask a student-generated question about the class and collect, analyze and interpret data based on student responses. The first question students asked was, "What kind of foods do we like?" Students surveyed each other on their favorite food. Then, they analyzed and interpreted the data to generate a claim about the foods students like most. The students generated claims based on the data, but were unable to provide clear and sufficient evidence to support their claims.

Then, I provided a set of questions for students to use as a guide when they analyzed and interpreted data. I called them Guiding Questions. The questions were:

1. What do you notice?
2. What do you see the most of?
3. What has the least?
4. How many more ___ than ___?
5. Are there any patterns?

I created an anchor chart with visuals for each question. Each time I modeled how to answer these questions with different types of data, I referred to the anchor chart. The students then independently used the anchor chart to answer the next question students asked, "What are we like after school?" Students collected data on the activity they liked to do after school and used the guiding questions on the anchor chart to independently analyze and interpret the data.

Visual thinking strategies were also used throughout lessons and during post-lesson reflections. Students made thinking visual primarily with argument partners and the constructive conversation protocol. After each lesson students shared the claims, evidence, and reasoning they generated or heard. These were listed on a chart and evaluated to determine student strengths and future steps. Students often independently referred to these charts during a lesson, using them as visual guides for how to analyze data or generate an argument.

Final findings. Each of these instructional scaffolds, in addition to those implemented to increase academic conversation and risk-taking mentioned in previous sections, served to transfer the responsibility of performing scientific practices from the teacher to the student. The need for the scaffolds slowly diminished as students gained proficiency in that practice. Student use of anchor charts and protocols was not constant throughout the study.

Student 15, a Caucasian male who qualified for free lunch, highlighted the entire table of data in the first performance assessment. On that assessment his claim was, "natural resources are data." During the seventh lesson, Student 15 analyzed and interpreted data to make this statement, "I think loam was the best because gravel took the shortest time for the water to come out and clay took the longest time." In the first two phases of the study Student 16, an African American female who did not quality for free or reduced lunch, avoided risks associated with critical thinking and only spoke three times. She was not able to analyze and interpret data on the first two performance assessments. In the eighth lesson she demonstrated her ability to analyze and interpret data by stating, "Maple was the only wood with all exes. Oak and Pine had 1 *X* so that means maple had 1 more *X* than oak and pine." She used this evidence to state her argument, "I think the strongest and hardest wood is the maple."

The scaffolds heavily supported student ability to analyze and interpret data in the third phase of the study. My field notes and PLC observations found the majority of students visually referred to the anchor chart of guided questions in the fifth lesson. The frequency of student statements coded as analyzing or interpreting data increased to 64% in the seventh lesson, but only one student was observed by my PLC to be using the anchor chart. At the end of the study, sixteen out of seventeen students were able to independently analyze and interpret data without using the guiding questions on the final performance assessment. The guided questions provided diminishing levels of support as students developed proficiency in generating a scientific argument from evidence.

Proficient Level of Scientific Inquiry

The literature defines inquiry on a variety of continuums. In their research, Walker and Shore (2015) found the inquiry process became problematic when the role of the teacher and student were not clear. It was essential to clarify the structure of inquiry and a continuum of proficiency to answer the research question: How does a focus on specific science practices maintain the level of science inquiry in a 1st grade classroom? Researchers described the levels of inquiry on continuums between teacher-directed and student directed (Aulls & Shore, 2008; Bell, Smetana & Binns, 2005; Rezba, Auldridge, & Rhea, 1999; Staver & Bay, 1987). This case study explores the shift in inquiry-based practices from structured inquiry to guided inquiry. Staver and Bay (1987) defined structured inquiry as a teacher leading the presentation of the problem and how to solve it. The teacher provides the questions or problem in guided inquiry, but the students guided the investigation and how to answer or solve the problem (Staver & Bay, 1987).

The protocol developed by Morton, Marshall, and White (2009) to guide and improve inquiry-based teaching and learning presented a benchmark for proficient and exemplary guided inquiry. Morton, Marshall, and White described instructional, discourse, assessment, and curriculum factors that impact proficient and exemplary inquiry. The findings of this study demonstrated that a focus on science practices impacted the proficiency level of scientific inquiry as described by the indicators of the EQUIP rating system.

Classroom observations conducted by my PLC were analyzed using provisional coding based on these indicators of the EQUIP rubric by Morton, Marshall, and White (2009). Descriptive coding was determined through subsequent coding cycles. Lesson transcripts and field notes were similarly coded to triangulate the data to answer the following research question: How does a focus on specific science practices maintain a proficient level of scientific inquiry in a 1st grade classroom? Data analysis found consistency between indicators of exemplary inquiry-based instruction as stated in the EQUIP protocol and classroom lessons focused on scientific practices.

Instructional Factors

A focus on scientific practices directly and indirectly influenced the proficiency level of scientific inquiry in my first grade classroom. The most significant impact the practice of generating an argument based on interpreted data had on inquiry-based practices was found in a shift of the order of instruction. In the first phase of the study the order of instruction began with student exploration, then moved to teacher explanation of concepts and phenomena. In the final phase of the study student explanation, not teacher explanation, followed student-led exploration. Instruction that focused on scientific practices required students to demonstrate a depth of understanding. This was an area of significant growth throughout the study seen in Table 4.11.

Students provide explanation. In their rubric, Morton, Marshall, and White (2009) stated that one element of exemplary inquiry-based learning was instruction that consistently asked students to provide explanation after exploration. The rubric assessment administered by the PLC found the teacher and students provided explanations at the beginning of the study. The teacher was the primary provider of explanations, establishing the level of inquiry-based learning to be on the developing level. Content analysis of student statements verified this observation. At the beginning of the study, students were able to share their thinking and interact in conversation, but their statements primarily reflected observations not explanations. The following dialogue interaction occurred during Lesson One:

Student 5: A cactus needs water.

Student 1: It holds water.

Student 6: Birds even drink the water.

The focus on scientific practices throughout each phase of the study increased student ability to state a claim with evidence. The increase in statements coded as claim or evidence encouraged a shift in student statements from observation-based to explanation-based. The process of generating a scientific argument using evidence provided students a clear structure of how to explain after they explored content or concepts. During the seventh lesson, one student said, “I think loam is the best type of soil because loam took a longer time for water to come out than gravel, but a shorter time than clay. Plants need water to grow.” The following is an excerpt from the eighth lesson:

Student 13: Maple didn't break, but peach and crepe myrtle did. Pine didn't break, but it did bend. Oak didn't break, but it did scratch. So Maple was the best.

Student 2: What's your reasoning?

Student 13: My reasoning is that if houses need wood that is strong, then maple is the strongest.

Table 4.11

*PLC Lesson Evaluation Using EQUIP Rubric (*Morton, Marshall, and White, 2009)

Instructional Factors	Phase 1	Phase 2	Phase 3	Phase 4
Order of Instruction	**Developing** Teacher asked students to explore concept before receiving explanation. Teacher explained	**Proficient** Teacher asked students to explore before explanation. Teacher and students explained.	**Proficient** Teacher asked students to explore before explanation. Teacher and students explained.	**Exemplary** Teacher asked students to explore before explanation. Though perhaps prompted by the teacher, students explained.
Teacher Role	**Developing** Teacher was the center of the lesson; occasionally acted a facilitator	**Proficient** Teacher frequently acted as a facilitator.	**Proficient** Teacher frequently acted as a facilitator.	**Exemplary** Teacher consistently and effectively acted as a facilitator.
Student Role	**Developing** Student learning focused on mastery of facts and process skills without much focus on understanding of content.	**Proficient** Student learning required application of concepts and process skills in new situations.	**Proficient** Student learning required application of concepts and process skills in new situations.	**Exemplary** Student learning required depth of understanding to be demonstrated related to content and process skills.

Lesson observations conducted by the PLC at the end of each phase found students explained more and the teacher explained less with each lesson. Content analysis of lesson transcripts found the frequency of statements coded as a claim with evidence more than doubled between the first four lessons and the last four, as Table 4.9 showed.

The increased frequency of student statements demonstrated the role of evidence in the scientific practice of generating an argument. A consistent focus on scientific practices led students to gain greater understanding of the purpose and value of evidence with each lesson. This increase in scientific literacy and scientific practices gave students the language and framework to explain a scientific concept or process. PLC observation of the order of instruction during the final two lessons found qualities of exemplary level inquiry-based instruction, according to the rubric by Morton, Marshall, and White (2009), seen in Table 4.11. Students consistently explained concepts after they explored, throughout both lessons in the final phase.

Student learning requires a depth of understanding. An instructional factor associated with exemplary inquiry-based instruction, according to Morton, Marshall, and White (2009) was that learning required a greater depth of understanding than what was necessary for the application of content and skills. PLC observations and teacher-researcher notes of the first phase of lessons found students were required to observe and analyze data to generate claims about the properties of natural objects. This level of knowledge acquisition aligned with the South Carolina Science Standards, but it did not provide students enough opportunities throughout a lesson to demonstrate a depth of understanding related to the concept of natural resources.

During the second lesson students collected, analyzed, and interpreted data to answer a question that emerged from the previous lesson. At the end of that lesson students generated their claim that answered the question, "Does a cactus need water?" Students took different sides of the argument based on their data analysis. When students took different sides of an argument and were expected to defend their claim the perspective on knowledge shifted. In that lesson, the students were not expected to regurgitate facts or apply a skill. They had to demonstrate a depth of understanding of what plants needed and how plants adapted to survive in different environments to justify their argument to a peer. The possibility of alternative arguments removed the authority of knowledge from the teacher or expert and gave it to my students. I reflected in my field notes that this lesson created a pivotal shift in how I approached instructional factors intended to provide opportunities for inquiry-based learning at the exemplary level.

I wanted to continue to focus on the properties of natural resources in the third lesson, but I chose to change the instructional strategy to greater mirror the scientific argument format due to the depth of understanding students demonstrated in the previous lesson. Students analyzed and interpreted data collected from natural resources to choose an argument that answered, “Are natural resources living?” Students used previous knowledge of the properties of living and nonliving objects and the data collected from different natural resources to generate and justify their answer. The argument format provided a safe environment for students to construct and reconstruct meaning. Students demonstrated a depth of understanding when asked to justify their claim. One student stated, “A lot of them have checks because they grow and use energy. But water does not grow and rocks don't grow or need water. Trees and other plants do though. Not all natural resources are living and all of them aren't nonliving so you can't take either side, living or nonliving.”

In the final phase of the study students demonstrated a new level of understanding by expanding upon their claims with scientific reasoning. In Lesson 8 a student said, “My reasoning is that you need a wood that is strong and stable to build a house with so maple is the best wood." On the final performance assessment students stated a claim regarding the best natural resource to make bricks for a house. A male English Language Learner (ELL) shared his claim, evidence and reasoning. His statement was one example of constructing new knowledge from conclusions independently drawn from data. Instead of focusing on the properties, the student focused on how the properties of natural resources impact the way they are used. I have corrected his grammar and spelling for readability.

> Clay is the best natural resource to make bricks with. The clay holds its shape when it dries and is stacked. The loam and gravel do not hold their shape. It needs to hold it shape so it can be strong. Not all natural resources are good for building.

Scientific practices provided a framework for me to release the responsibility of knowledge acquisition to my students. Students increasingly drew their own conclusions from the data over the course of the study, demonstrating a depth of understanding that would not have been possible if an expert or I provided the conclusions following exploration. The PLC recognized student learning in the final phase of the study required a depth of understanding, though not consistently. This is an area for continued growth and focus following the study and will be addressed in the action plan in Chapter 5.

Patterns of Communication

The primary intention of this study was to investigate the instructional factors that promote the proficiency of scientific practice in a first grade classroom, and to evaluate how that process impacted scientific inquiry. Patterns of communication were not of central interest to that original intent. As the study progressed, communication became a key factor in the development of student proficiency in the practices of analyzing and interpreting data and generating a scientific argument. Morton, Marshall, and White

(2009) described levels of discourse factors along a continuum of inquiry-based instruction in the EQUIP rubric. The PLC used this rubric to determine how the patterns of communication during each lesson changed as students gained proficiency in scientific practices. The PLC found all aspects of communication patterns during the first two lessons were on the developing level of inquiry-based instruction, shown in Table 4.12. A focus on scientific practices shifted communication patterns to reflect exemplary inquiry-based instruction by the end of the study.

Classroom interactions. The Constructive Conversation Protocol gave students a framework for the classroom interactions associated with exemplary inquiry-based instruction that Morton, Marshall, and White (2009) described in their rubric of discourse factors. Morton, Marshall, and White stated that exemplary inquiry-based instruction includes interactions in which the teacher facilitates classroom dialogue where evidence, assumptions and reasoning are challenged. This level of discourse was not occurring at the beginning of this study. Content analysis, PLC observations, and teacher-researcher field notes found classroom interactions were not conversational. A significant amount of statements were transcribed, but reciprocity in which the students exchanged, challenged, or expanded upon those statements with each other was not evident in video observations conducted by the PLC.

Content analysis of dialogue that took place as students used the Constructive Conversation Protocol during the final phase of the study found scientific vocabulary words were used in discussions at a greater frequency than in previous phases. A focus on scientific practice provided students with the academic vocabulary necessary for them to challenge evidence, assumptions, and reasoning through discourse. The following frequency table demonstrates the increase in the use of vocabulary related to scientific practices of generating arguments based on data throughout the study. As shown by Table 4.13, students began using the terms claim, evidence, and reasoning within conversation after the terms had been modeled and labeled by the teacher in conversation over the course of four lessons.

Table 4.12

PLC Lesson Evaluation Using EQUIP Rubric (Morton, Marshall, and White, 2009)

Discourse Factors	Phase 1	Phase 2	Phase 3	Phase 4
Communication Pattern	**Developing** Communication typically controlled by the teacher with occasional input by other students, mostly didactic pattern.	**Proficient** Communication was often conversational with some student questions guiding the discussion.	**Proficient** Communication was often conversational with some student questions guiding the discussion.	**Exemplary** Communication was consistently conversational with student questions often guiding the discussions.
Classroom Interactions	**Developing** Teacher or another student occasionally followed up student response with further low-level probe	**Developing** Teacher or another student occasionally followed up student response with further low-level probe	**Proficient** Teacher or another student often followed up response with engaging probe that required student to justify reasoning or evidence.	**Exemplary** Teacher consistently facilitated rich classroom dialogue where evidence, assumptions, and reasoning were challenged by teacher or other students.

Table 4.13

Number of Student Statements including Vocabulary Associated with Scientific Practices

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8
Claim/ Argument	0	1	1	1	10	9	12	11
Evidence	0	1	1	0	12	9	16	17
Reasoning	0	1	0	0	2	9	6	12

The focus on scientific practices clarified the purpose and action of negotiating meaning with others through dialogue. The role of evidence became central to classroom interactions in the final phase of the study, as seen in the growing use of the term evidence in student-to-student conversations in Table 4.13. When students were unable to provide convincing evidence to support their claim, it provided an opportunity for others to challenge misconceptions or assumptions. During Lesson 6 a small group of students challenged a claim stated by a member of the group by reviewing the evidence. Evidence was a tool that allowed the students to challenge another student respectfully. After reviewing the evidence, the student who was being challenged modified his claim. Additionally, the interaction gave other members of the group an opportunity to demonstrate a depth of understanding of how rocks were formed.

Student 15: It's an igneous rock.

Student 4: Let's look at the evidence. One is, its brown.

Student 12: It has stripes.

Student 7: I see layers.

Student 12: The stripes probably mean it is the kind that has shells and other things pressed together for a long time until it becomes a rock.

Student 7: Yeah, that’s what the layers are!

Student 4: Then it can't be an igneous rock because that’s the one made of hard lava.

Student 15: Then it is a sedimentary rock.

Student questions guiding discussion. Throughout the first few phases of this study, the theme of questioning consistently emerged. Using the rubric created by Morton, Marshall, and White (2009), the PLC determined the teacher typically controlled communication during the first three phases of the study. Despite the high frequency of student statements that occurred during each lesson, student questions rarely guided the discussion. Content analysis confirmed this observation. A total of two students asked a question to extend a discussion throughout the entirety of Phase 2 and Phase 3. This is an example of the communication patterns that occurred in the classroom as we just started to focus on scientific practices. A student asked a question to his peers, but it does not serve to guide or further the discussion. Nor did the student question lead the students in a conversation that included reciprocal communication.

Student 9: I don’t know what the evidence could be.

Student 11: Can you tell me what it says? It says living and nonliving.

Student 18: Trees are one.

Student 14: They are all natural resources.

Student 9: I don’t know any.

In the final phase of the study students asked all of the questions guiding discussions surrounding data analysis and scientific arguments. Approximately 20% of student statements in Lessons 7 and 8 were coded as student-to-student questions. In

Lesson 7, students discussed the data collected during an experiment to determine which natural resource would be best for plants. Student-to-student questioning allowed the students to construct meaning as they interacted with each other. Communication in Lesson 7 reflected reciprocal conversation.

Student 9: If the soil is really dry will the plant grow?

Student 6: I think no because if the soil is dry then I think it won't have enough water for the plant to stay healthy.

Student 7: What if the dirt is super wet?

Student 2: I think it needs to just be a little bit of wet.

As students' increased proficiency in scientific literacy and practices, they began to demonstrate more constructive and empowered behaviors than compliant. In the final lesson, students used the Constructive Conversation Protocol to create a communication pattern aligned with the factors associated with exemplary inquiry-based instruction described by Morton, Marshall, and White (2009). Students led their learning through peer-to-peer dialogue that required students to explain, justify, and reason. The following is an excerpt of dialogue from Lesson Eight. Both students in this conversation were girls who demonstrated compliant behaviors in the first two phases of this study, and rarely contributed original thoughts to a conversation. As previously mentioned, during the first two phases Student 16 only had three coded statements. In the final phase both students demonstrated risk-taking and empowered behaviors by sharing ideas that may be different from that of another student and negotiating meaning by building upon and adjusting their thinking.

Student 4: My claim is pine, oak, or maple would be best to build a house with.

Student 16: I thought the best meant we picked one.

Student 4: But all three would be better than the others.

Student 16: What's your evidence?

Student 4: Oak, maple, and pine don't break, but peach and crepe myrtle do.

Student 16: I think the strongest and hardest wood is the maple.

Student 4: What's your evidence?

Student 16: Maple was the only wood with all exes. Oak and Pine had 1 *X* so that means maple had 1 more *X* than oak and pine.

Student 4: So that makes maple better than oak and pine?

Student 16: I think so, because the question asked which one was the best.

Student 4: Do you have reasoning?

Student 16: The best wood for a house would not bend, break, or scratch.

Student 4: I get it. Strong wood doesn't bend, but it also doesn’t break and scratch.

Students consistently and effectively active as learners. The teacher consistently and effectively acts as a facilitator in inquiry-based instruction at the exemplary level according to Morton, Marshall, and White (2009). The growth in student proficiency of providing explanation of a concept and demonstrating a depth of understanding as a result of a focus on scientific practices addressed the problem of practice established prior to conducting this study. The instructional factors and classroom interactions that occurred during lessons focused on generating an argument from analyzed or interpreted data allowed me to release the responsibility of learning to the students. As a result, students were consistently and actively engaged in learning.

One discourse factor that was observed by the PLC as students gained proficiency in the process of argumentation was that students were often teaching their peers as they justified a claim. Students challenged their peers to provide evidence to support their claim. Students adjusted or altered an original argument when they were not able to justify the claim convincingly to a peer, or when a peer provided alternative or new evidence. In the third phase of the study three students modified their claim as a peer challenged them. Eight students in the final phase adjusted their argument as a result of interactions with a peer. The structure of classroom discourse centered on scientific practices increased active engagement in the learning process.

Conclusion

This chapter presented the analysis and findings of data collected from lessons in a first grade classroom of seventeen students. Action research was conducted across four phases to explore how students develop a proficiency in generating an argument from evidence and how this focus on scientific practices would impact the proficiency level of scientific inquiry in the first grade classroom.

Performance assessments administered at the end of each phase in the study found the instructional strategies implemented in each phase positively impacted student proficiency in the scientific practices of analyzing or interpreting data and generating a scientific argument based on evidence. Content analysis of lesson transcripts, lesson observations conducted by my Professional Learning Community (PLC), and my teacher-researcher field notes found students increased proficiency of scientific practices primarily through instructional strategies organized by three themes: engaging in academic conversations, taking risks, and interacting along a continuum of learning scaffolds.

Observations conducted by my PLC found lessons focused on scientific practices moved inquiry-based instruction from the developing to the exemplary level based on the EQUIP rubric developed by Morton, Marshall, and White (2009). Content analysis of lesson transcripts, PLC lesson observations, and field notes found instructional factors and discourse factors impacted this progression of inquiry-based practices. One instructional factor that occurred as lessons focused on scientific practice was a change from the teacher to the students providing explanations consistently following explorations. A focus on scientific practices also created a situation in which student learning required a depth of understanding. The communication patterns between students also changed with a focus on scientific practices. Classroom interactions consistently involved dialogue in which students challenged the evidence, assumptions and reasoning of their peers by the final phase of the study. Students learned to guide their discussions with student-to-student questioning. All of these factors are factors of exemplary inquiry-based instruction according to Morton, Marshall, and White (2009).

The qualitative case study design was used to find a focus on developing first grader proficiency in scientific practices impacted inquiry-based instruction. The findings presented in this chapter demonstrated that students were consistently and effectively active learners at the end of the study. Limitations of this study impact the ability to assume the instructional strategies and practices presented in this chapter can be applied to any educational context with the same level of success. In Chapter 5, these limitations will be considered. The conclusions, action plan, and implications for further research will be discussed.

Chapter 5:

Implications and Recommendations

This action research study began with the identification of a problem of practice recognized in a first-grade classroom. I observed a discrepancy between my instructional intent and practice of inquiry-based teaching and learning. Students did not demonstrate proficiency in scientific practices or scientific inquiry as a result of this deviation from plan to practice. This Dissertation in Practice (DP) evolved from a desire to find strategies to increase the proficiency of inquiry-based instructional practices through a focus on the scientific practices of analyzing data and generating a scientific argument.

The final two phases of the action research cycle, reflecting and developing, were presented in this chapter. Reflection of the DP was conducted and described in the overview of the study and a discussion of the findings. Implications and limitations of the study were discussed, and the chapter concluded with an action plan for future steps and research based on the findings of the study.

Overview of the Study

The purpose of this study was to explore the factors that impact the proficiency level of inquiry-based instruction in a first-grade classroom. A qualitative case study design was employed to investigate how students increase the ability to analyze and interpret data to generate a scientific argument, and how a focus on these scientific practices impacted the level of inquiry-based instruction. Seventeen first grade students participated in lessons divided into four phases. Performance assessments were administered to students following each phase. At the end of each phase, I reflected on performance assessment results and behaviors and discourse demonstrated by student and teacher participants during the lessons. These reflections were used to adjust or revise instructional interventions in each subsequent phase. Each intervention was designed to increase student proficiency in the two scientific practices investigated.

Performance assessments were administered four times to evaluate student proficiency in generating scientific arguments and analyzing and interpreting data. Eight lessons were video recorded and transcribed. Transcriptions were initially coded through deductive analysis using the provisional codes claim, evidence, and reasoning chosen in advance based on the elements of a scientific argument. Transcribed lessons were also coded inductively through descriptive coding that was derived from student and teacher statements or actions. Multiple cycles of content analysis reduced codes and identified larger subthemes and themes related to each research question. Six colleagues who composed my Professional Learning Community (PLC) evaluated lessons by observing video recordings and rating them using the EQUIP rubric developed by Morton, Marshall, and White (2009) at the end of each phase of the study. Teacher-researcher field notes were recorded throughout the study and reduced into analytic memos. Memos were coded descriptively to verify and triangulate the data collected.

Discussion of Findings

The key themes that emerged from the data analysis process confirmed the theory of social constructivism associated with inquiry-based practices. According to the constructivist theory, the learner creates knowledge and understandings through experiences and interactions (Bruner, 1990; Prince & Felder, 2006). Vygotsky (1978) expanded on the constructivist theory of learning with the argument that social interaction improved the construction of meaning for the group and the individual. The findings of this study verified that argument. All of the discourse and instructional factors found to increase proficiency in scientific and inquiry-based practices required students to interact socially to construct, explain, and defend meaning.

Students developed proficiency in the scientific practices of generating arguments and analyzing and interpreting data as a result of instructional strategies implemented throughout the study. At the beginning of the study zero students were able to independently generate a claim with two or more pieces of evidence from analyzed or interpreted data. On the final performance assessment, every student demonstrated the ability to generate a scientific claim. 94% of students were able to independently identify patterns and infer relationships from data to provide two or more pieces of evidence to the support their claim. 88% of those students connected the evidence to their claim with scientific reasoning.

A consistent focus on scientific practices across the four phases of this study gradually took the focus off the content and the teacher as the source of knowledge and on the student. Instruction and discourse factors moved from the developing level of inquiry-based instruction to the exemplary level when student proficiency in generating an argument from the evidence was at the heart of classroom interactions. Instructional strategies that encouraged teacher and student risk-taking, while providing various levels of support, had the most significant impact on student competence.

The instructional scaffolds with the most significant influence on student proficiency were conversation protocols that encouraged students to make their thinking visible through structured academic conversations. Students began to defend arguments and negotiate meaning through reciprocal and collaborative discourse. Intentional student-to-student dialogue shifted student behavior from compliant and disengaged at the beginning of the study, to constructive and empowered at the conclusion. The shift in behaviors to constructive and empowered directly impacted student performance of scientific practices and created a culture of risk-taking and inquiry in the classroom community.

Implications for Future Practice

The development of scientific literacy and achievement in young learners has been found to impact future science achievement for students of all social groups, especially those identified as minorities. According to Morgan, Farkas, Hillemieier, Maczuga (2016), the development of science achievement in primary grades was highly predictive of science achievement in the future. Curran and Kellogg (2016) discovered racial, and gender achievement gaps widened considerably between kindergarten and third grade and remained consistent into high school. An insignificant amount of research in the literature explored specific strategies to increase student proficiency in scientific practices in primary grades. The findings from this study provided implications for personal and professional practice that could also be applied to K-12 learning and broader policies of curriculum and instruction.

The advancement in student proficiency in the practice of generating an argument that included a claim, scientific reasoning and multiple pieces of relevant evidence was in contrast to findings discussed in the literature review. Multiple studies found students in the early elementary grades dominated discourse with unsupported claims consisting of insufficient or no reasoning (Bullock & Ziegler, 1999; Hardy, Kloetzer, Moeller, Sodian, 2010; Kuhn, Black, Keselman, and Kaplan, 2000). An assumption prevalent in the literature was that early elementary students did not have the reasoning abilities or conceptual knowledge to engage in scientific practices (Chen, Hand, & Norton-Meier, 2016; Lehrer & Schauble, 2006; Metz, 2011). In their book, Zemball-Saul, McNeill, and Hershberger (2013) claimed students in third grade or higher effectively generated scientific reasoning in the argument framework. The level of student proficiency demonstrated by the first-grade students in this study provided evidence that first graders have the cognitive ability to effectively reason and analyze data to support scientific claims when instructional and discourse supports empower them as thinkers and learners.

The contradiction between study findings and previous research suggesting that students in early elementary grades do not have the cognitive abilities or conceptual knowledge to proficiently engage in scientific practices and inquiry-based learning generated implications for future practice that were not considered previous to this study. First-grade students in this study developed proficiency in scientific practices when their teacher was willing to take risks and work through the struggles that come with a shift in instructional and discursive practices. This finding implied that teacher and student risk-taking was an essential element of interventions addressing deficiencies in the present and future science achievement. Educators have a responsibility to acknowledge and persevere through moments of fear or disruptions that occur as teachers release total control of the learning process and increase student agency. This is an essential step in the development of proficiency in scientific practices in young students, and erasing the persistent achievement gaps Curran and Kellogg (2016) reported.

Implications for Personal Practice

This study began out of a problem of practice that was observed and investigated in some form by my PLC and myself over the course of five years. Previous to this study I had many assumptions as to the source of the discrepancy between intentions and practice. Two areas of my practice I had never considered before this study were identified after the study to be essential to inquiry-based and best teaching practices: setting clear expectations and replacing a focus on compliance with empowerment.

Establishing clear expectations. I attended multiple and varied training related to inquiry-based teaching and learning practices over the past ten years, yet I continued to have difficulty authentically implementing those practices in my classroom. As I reviewed the literature related to inquiry-based learning, I discovered the EQUIP rubric created by Marshall, Horton, and White (2009). This document illuminated the areas of personal practice that did not reflect exemplary inquiry-based instruction. My PLC and I reflected that we gained a greater understanding of our practice with each interaction with the rubric throughout the study. For example, at the beginning of the study, we believed I consistently acted as a facilitator. However, with continued evaluation of lessons over the course of the study, we refined our understanding of the role of a teacher facilitator and readjusted the initial rubric scores to reflect our new perspective. The clear and specific expectations described in the EQUIP rubric served as a guideline to compare lessons and identify new strengths and weaknesses in my practice. These expectations were the missing link between my intention and actual implementation of inquiry-based teaching and learning previous to the study.

I often used rubrics to provide students with specific levels of performance. However, I'd never thought of the need for an instructional rubric. When a problem of practice emerges in the future, my initial step will be to define the behaviors or expectations at each level of proficiency. Concerning my current problem of practice, I will continue to use this rubric to gauge instructional and discourse interventions implemented in my classroom so that I can maintain and further refine excellent inquiry-based teaching.

I discovered that my students benefited from clear and specific expectations as well. Scientific practices provided distinct student actions of inquiry-based learning. A focus on these practices shifted the level of inquiry demonstrated by students from developing to exemplary because they clarified how scientists answered their questions and revised their thinking to generate theories and arguments. Their ability to share and expand upon ideas flourished when conversation norms and protocols were established and practiced. Students were not able to construct and challenge meaning through the dialogue until they had a clear framework of the language and interactions of a constructive conversation.

Clear and specific expectations will be an essential element to any future instructional intervention. This element is especially true for scientific practices or any other type of process or cognitive skill. As an example, I will now provide students with explicit models of how to evaluate or defend ideas. Once students have clear expectations of what they do in the process that generates or evaluates ideas, they will construct meaning independently. In the future, clear expectations of how to think will replace specific expectations of what to think about science concepts or any other subject.

Compliance versus empowerment. Previous to this study, I never investigated the contrast of compliant and constructive or empowered behaviors. I mistakenly assumed I created conditions for my students that encouraged them to be empowered learners because my instructional strategies required them to collaborate in groups and to create projects or solve problems. This study identified some issues with my assumption. Compliant students required no teacher risk-taking or professional struggle. In part, the prevalence of student compliance in my classroom created this problem of practice. I believed the sources for the discrepancy that existed in my classroom environment between inquiry-based instruction and inquiry-based learning was student ability. This study illuminated the actual source for that discrepancy was not the student but the teacher.

Content analysis of the first phase of lessons in this study highlighted my focus on compliant behaviors. Following that analysis, I reflected that I often celebrated compliance out of personal motivation to avoid interacting with disengaged and disruptive student behaviors during a lesson. The study found that I acted out of a fear of behaviors that rarely occurred in reality. Instructional strategies that encouraged student compliance inadvertently stripped students of constructive and empowering experiences. An increased focus on scientific practices established the need for instructional strategies that gave priority to constructive and empowered behaviors. Realigning classroom practices to encourage student behaviors that were less compliant and more constructive required a significant amount of student and teacher risk.

As I approach innovative and student-centered practices in the future, I will measure student behavior by the levels of engagement defined as a result of this study, ranging from disruptive and disengaged to constructive and empowered. My goal is to refine and expand upon my practice to empower my learners consistently. I now see student empowerment as both the source and the effect of inquiry-based scientific practices. In connection with the relevance of setting clear expectations, I will create a rubric of empowering instructional practices similar to the EQUIP rubric by Marshall, Horton, and White (2009) to evaluate my practice in science and all other subjects as I continue to grow in this area.

Implications for K–12 Learning

The instructional and discourse factors that applied to future practice in my first-grade classroom could also be applied in whole or in part to science and inquiry-based practices in classroom communities of my colleagues and other K-12 teachers. Instructional interventions employed to increase science achievement that were prevalent in the research were content-specific teaching strategies (Grant & Fisher, 2010; Pearson, Moje, & Greenleaf, 2010; van Driel, Berry, & Meirink, 2014), inquiry-based scientific practices (Darling-Hammond, 2008, Minner, Levy, & Century, 2009; Shoenfeld, 2002), and scientific literacy and vocabulary development (Bybee, 1997; Osborne & Dillon, 2008; Romance & Vitale, 2001; Williams, Stafford, Lauer, Hall & Pollini, 2009). The literature provided a significant amount of general approaches to instruction, but it offered very little research regarding specific methods found to develop inquiry-based scientific practices or scientific literacy for young learners.

As discussed in the review of the literature, the research found inquiry-based scientific practices significantly improved science achievement (Briars, 2001; Darling-Hammond, 2008; Geier, Blumenfled, Marx, Krajcik, Fishman, Soloway, & Clay-Chambers, 2008; Minner, Levy, & Century, 2009; Shoenfeld, 2002). Researchers argued that many of the discrepancies between educational practices based in the social constructivist theory, such as inquiry-based learning or argumentation, and effective implementation of those practices stemmed from the cognitive abilities of students and the absence of cognitive skills in the curriculum (Barak & Shakhman, 2008; Chen, Hand, & Norton-Meier, 2016; Kuhn, Black, Keselman, and Kaplan, 2000). The findings of this study highlighted how classroom interactions and student-centered scaffolding, not the cognitive capabilities of students, created an environment in which students participated in and initiated the co-construction of knowledge and understanding. Through protocols and guiding questions, students were able to express and expose their cognitive skills in the curriculum. These two interventions enhanced student and teacher proficiency in inquiry and scientific practices.

Classroom interactions in a community of practice. This study demonstrated that student proficiency in critical thinking skills and scientific practice could be enhanced or hampered depending on the structure and type of interaction. A shared understanding was enhanced when students used academic conversations to build upon ideas in student-to-student dialogue. Previous research related to scaffolding purposeful academic dialogue to guide students to elaborate on and deepen their thinking focused on teacher prompts through open-ended questioning (Colley & Windschitl, 2016; Minstrell & van Zee, 2003; Nystrand, Wu, Gamoran, Zeiser, & Long, 2003; Wasik and Iannone-

Campbell, 2012). The findings of this study found student-to-student prompts generated more active and constructive conversations than teacher-to-student prompts significantly.

Reflecting on the problem of practice before conducting this study, I believed the element creating the most significant barrier to inquiry-based learning was a student deficiency in inquiry literacy. I assumed that my students knew how to ask questions and to explore concepts, but they did not know how to explain their learning or construct meaning independently. The conversation scaffolds originally planned to enhance academic conversations included sentence stems and other supports to increase and strengthen scientific and inquiry literacy. The findings of this study provided a different perspective of how literacy impacted inquiry than that of my original assumption. Scaffolds and supports did not impact classroom interactions until students understood the purpose and process of student-to-student academic conversation.

At the beginning of the study, students regularly engaged in dialogue. Content analysis of lesson transcripts found the presence of student dialogue did not create effective interactions. Students continued to interact parallel to each other until I provided clear expectations of how to engage in academic conversation through the Constructive Conversation Protocol. Previous to this study I predicted the problem of practice would be best addressed through teacher modeling of how to draw conclusions and think critically through a process of cognitive apprenticeship. The conversation protocol allowed students to provide cognitive apprenticeship to their peers. These interactions had a significant impact on student inquiry because they removed the teacher from the center of the lesson and allowed me to effectively and consistently act as the facilitator.

This study implied the value of academic conversations in future practice for grades K-12. Zwiers and Hamerla (2018) verified my findings that very little research on peer conversations with elementary students existed in the literature. Classroom interactions that consisted primarily of student-to-student dialogue created more active learners. As this study demonstrated, a few factors were necessary for meaningful and constructive discourse to occur. One essential element was the development of a community of practice by establishing a common goal. Clear expectations through norms, visuals, and protocols established before any classroom interactions created a community that worked towards a shared and constructive purpose. Student-to-student prompts, and questioning was another essential element to student engagement. Students actively engaged with their peers when they guided the discussions. This study contradicted my unspoken teacher-fear that students could not learn and understand content or concepts adequately if I consistently acted as a facilitator. My first-grade students demonstrated the most significant depth of understanding of content and concepts during structured student-to-student academic conversation.

A critical factor in the development of student proficiency in scientific and inquiry-based practices in future practice, especially in Kindergarten through Second Grade, will be the level and type of classroom interactions. A focus on student-to-student prompting and conversation protocols will scaffold constructive dialogue and increase student independence. Purposeful and constructive classroom interactions should dominate scientific learning. The EQUIP rubric of discourse factors of inquiry-based learning by Marshall, Horton, and White (2009) is an excellent tool for educators to use as a guide.

Scaffolding. The research presented in the literature review found the degree of teacher scaffolding was a crucial factor in the level of student proficiency and engagement in inquiry-based practices (Levy, Aiyebayo & Little (2009); Schmid & Bogner (2015); Wang, Kinzie, McGuire, & Pan, 2010). Song and Kong (2014) argued that the form of scaffolding provided to students and the level of student prior knowledge had the most significant impact on a student's ability to engage in inquiry. This study verified those findings. The concept of scaffolding as support for student-led inquiry often felt counterintuitive to the idea that students were leading their learning, but as this study demonstrated it was a necessary tool for student empowerment.

Modeling often involves mimicry. While mimicry has always been a crucial step in the learning cycle for early learners, this type of learning aligned more with the definition of structured inquiry described by Staver and Bay (1987). The purpose of this study was to move teaching practices from structured inquiry to guided inquiry. Staver and Bay's (1987) definition of guided inquiry and the EQUIP rubric by Morton, Marshall, and White (2009) established the role of the teacher to be a facilitator. This facilitator role dictated a need for scaffolding to move beyond mimicry of the teacher to student-led construction and reconstruction of meaning.

The findings of this study suggested that a significant factor in the use of scaffolding to empower learners and support students in the practice of socially constructing and expanding upon meaning was what was scaffolded. When I supported students in a teacher-centered or content-based conclusion or answer, my students demonstrated compliant or disruptive and disengaged behaviors. As I gradually shifted the role of scaffolding to support students in the process of co-constructing meaning through student-to-student interactions, my first-grade students began to expand on ideas, develop scientific reasoning, and challenge peer assumptions. These constructive and empowered behaviors were not evident when scaffolding served to model and support one specific way of thinking or conclusion.

This study demonstrated the temporary support that is critical to the concept of scaffolding. As students gained independence and confidence in the use of guiding questions to analyze or interpret data, their use of the anchor chart tapered and their proficiency increased. Similarly, students slowly reduced their reliance on sentence stems and began to alter the steps of specific protocols as constructive conversation became more natural and automatic. This phenomenon reiterated the idea that the scaffold is not the primary focus of scientific or inquiry-based practice. The purpose of the scaffold is to temporarily support students in the process of constructing and co-constructing meaning.

The use of scaffolds will benefit student proficiency in scientific or inquiry-based practices in future practice of K-12 classrooms. However, scaffolds will promote a culture of empowered, constructive, and critical thinkers when they support the process of social construction. Teachers of all grades will encourage a depth of understanding of content or concepts when they shift the role of scaffolding from supporting the mimicry of modeled content-based skills to supporting purposeful approaches to student-led interaction and learning. Teachers can do this through tools such as guiding questions, protocols, decision prompts, and student-to-student prompts.

Evidence-based argumentation. Another theme that I did not consider previous to this study was the impact of evidence-based argumentation on student learning and engagement. For many years previous to this study, learning that required students to demonstrate a depth of understanding related to content and process skills remained an elusive process to students. The research claimed the sources for this discrepancy between student behavior and teacher intention was student ability (Chen, Hand, & Norton-Meier, 2016; Lehrer & Schauble, 2006; Metz, 2011). Argumentation gave students a purpose for analyzing and interpreting evidence and evaluating the relevance of that evidence. The development of the practice of argumentation provided students a purpose of making their thinking public and visible. Students were self-motivated to defend and expand their thinking as they interacted with peers. Student proficiency in providing scientific reasoning to support claims developed over the course of the study as a byproduct of the student practice of argumentation.

Argumentation was such a powerful practice that students independently employed it in other settings. In non-academic settings, students would ask peers to defend their statement with evidence. For example, at lunch one day a student said the tooth fairy was not real. The other students sitting near him said, "Prove it, what's your evidence?" The student then listed different clues that proved his parents were acting as the tooth fairy. The process of argumentation increased student proficiency in writing craft, reading comprehension, and a variety of math concepts. During math, I required students to generate an argument that included a claim, evidence, and reasoning to answer which number representation did not belong or what was the solution to a real-world problem. The development of evidence-based argumentation encouraged students to demonstrate an understanding of a concept or content with a depth of understanding in all subject areas.

Evidence-based argumentation also had a significant impact on student voice. Students across a variety of demographic groups interacted in lessons at the beginning of the study. However, every student who did not participate in collaborative learning activities or discourse at the beginning of the study was labeled demographically as a social minority. Each lesson in which evidence-based argumentation was the primary instructional practice, as seen in the findings of the study, increased student participation and student voice for all students, especially those who hesitated or resisted participation in lessons with an absence of argumentation. The students who demonstrated the most considerable growth in participation and voice through argumentation were English Language Learners (ELL). This finding has significant implication for increasing student voice and minority representation in science achievement.

These findings position argumentation as an invaluable addition to future classroom practice for students in Grade K–12. Educators will increase science achievement for all learners when evidence-based argumentation is a consistent classroom practice. This implication also positions argumentation as a critical factor in diminishing the persistent achievement gap Curran and Kellogg (2016) describe. Future practice includes the need to refine and expand upon the use of scientific practices that increase student voice by repositioning the focus of academic power on the evidence the student provides, not the student. Classrooms that focus on the role of evidence instead of the right answer will inadvertently create a culture of social justice in which students of various levels of social or academic capital interact on the same level.

Recommendations for Policy Implications

Students and teachers would benefit from a refocus of the district, state, and national policy and education initiatives based on the implications previously discussed. The broader implication for future policy is to shift the focus from a culture of accountability to a culture of risk-taking. The accountability movement that began in the 80s continues to limit the curriculum and teacher practice because it encourages compliance, not empowerment. The shift in educational practice that is necessary to empower students to be engaged and independent and social thinkers and learners that can later contribute to an innovation-driven society involves significant teacher risks and effort. This type of risk-taking can only occur when teachers are supported and celebrated through the process.

An increased focus on science practices in the early elementary grades is imperative. Currently national and state science curriculum materials provide examples of each practice by grade level and suggest specific practices to implement with each standards-based unit. Standards-based units continue to center around content and activities. This study demonstrates that science instruction focused heavily on content and activities are inadequate in providing students with learning experiences that require a depth of understanding. Future science curriculum and instruction development need a greater focus on scientific practices and their impact on science achievement.

Limitations

The nature of an action research study does not allow me to generalize the implications of these results to other populations. The recommendations presented do not imply that the unique interactions in my first-grade classroom can be replicated with other students. The purpose of the recommendations is to continue to strive to create an environment in which my students, in this current class and of future classes, are equipped and empowered to construct meaning and defend their explanations with evidence.

The findings of this study are also limited by the use of video recording in lesson observations and transcripts. Many statements were inaudible on the video playback and were not included in the transcripts as a result. The omission of those statements affected the frequency of coded claims or arguments generated based on evidence and the coding of other scientific comments.

Additionally, pieces and artifacts excluded from lesson transcripts had the potential to alter the findings. Student claims or reasoning with supporting evidence that was written during each lesson were not included in lesson transcripts. The reflection piece of each lesson was not video recorded, so the data related to student proficiency provided during these sessions were excluded from this study. At the end of the study, I noted that the reflection piece of the lesson was a crucial factor in increased study proficiency. Student reflections were referenced in teacher field notes, but they were not transcribed for content analysis or analyzed in PLC observations.

My Professional Learning Community (PLC) and I scored the inquiry-based instruction observed in the first two lessons as proficient in the areas of Order Instruction and Knowledge Acquisition on the EQUIP rubric by Morton, Marshall, and White (2009). After observing student learning that required an application of concepts in the following two lessons, the team determined that same level of knowledge acquisition was not present in the first two lessons. The PLC changed the original rating of the first phase of lessons from proficient to developing. The rating of the instruction order moved down from proficient to developing for the same reason. These changes provided evidence that the PLC did not have a complete and deep understanding of how the factors listed in the EQUIP rubric are demonstrated in the classroom. This growing understanding of the factors present in exemplary inquiry-based instruction exhibited by my PLC and myself potentially limited the findings of this study.

Action Plan

The purpose of this action research study was to explore how scientific practice impacted inquiry-based instruction in my classroom. The implications for practice discussed in the previous sections served as the primary guide in the development of this action plan. The action plan is divided into two phases.

Phase 1

The secondary purpose of this DP was to design an action plan to increase scholarly science achievement by maintaining a proficient student-centered inquiry approach to learning. The first phase of the action plan consists of two goals for personal practice to address that purpose with the students of my first-grade classroom. This study implies the scientific practice of argumentation plays a critical role in science achievement and depth of understanding for first-grade students. This action plan includes an amplified focus on argumentation to further the scholarly science achievement of my students.

The results of this study suggest a priority for constructive academic peer-to-peer conversation in an inquiry-based science classroom. As a result of this finding I am committed to further refining conversation protocols explored in this study and expanding the list of tools available to support students in constructive and empowered communication. This commitment is the source for the first goal of Phase 1. The second goal of the first phase stems from the role of argumentation in student learning and understanding of science content and concepts that was revealed through this study. A qualitative case study will be deigned to explore how students become more independent and expressive thinkers through argumentation rather than retelling ideas or replicating teacher thinking. This study will encompass the two goals of this action plan to continue the process of refining teacher practice to improve science achievement for all learners in my classroom.

Goal 1. In the first six weeks of the 2018-2019 school year, I will conduct a qualitative case study to investigate the impact of a variety of discourse protocols and student-to-student prompts on argumentation proficiency of the first-grade students in my classroom. Similar to the EQUIP rubric by Marshall, Horton, and White (2009), a rubric describing proficiency levels of student and teacher behaviors in argumentation-based instruction will be developed using the factors of argumentation described by the National Research Council (2012) in the Framework. This rubric will be used to measure student and teacher growth and further refine and expand on the practice of argumentation in my classroom.

The qualitative case study design will include four phases similar to the design of this study. Before the start of the study, and at the end of each subsequent phase a performance assessment will be administered. The argumentation rubric will be used to assess student proficiency level. Teacher and student discourse will be recorded and transcribed throughout the study. I will record teacher-researcher field notes and my PLC will use the argumentation rubric to evaluate argumentation-based instruction and student-led argumentation practices. At the end of each phase results of each performance assessment, as well as content analysis of transcripts, field notes, and PLC observations will be used to develop and refine additional constructive conversation protocols that increase student proficiency in argumentation.

The purpose of first goal of this action plan is to investigate specific discussion protocols that support students in refining communication skills to more proficiently participate in scientific argumentation. Zwiers, O'Hara, and Pritchard (2014) list five core communication skills that younger students develop through focused and scaffolded instruction. The protocols and other scaffolds investigated will focus on these core skills: listen actively, create, clarify, support ideas, and evaluate (Zwiers, O'Hara, & Prichard, 2014). As in this DP, the focus will not be on the discourse scaffolds, but on the use of scaffolds to increase student risk-taking, independence and confidence.

Goal 2. In connection with the first goal of this action plan, the second goal is to determine how an increase in student argumentation impacts the depth of understanding of scientific content or concepts demonstrated by my first-grade students. In the final phase of the study the PLC noted during lesson observations that student learning required a depth of understanding, but that observation was not a consistent feature across an entire lesson. This finding determined an area of continued growth should be that students demonstrate learning through a depth of understanding consistently throughout a lesson.

The second focus of the qualitative study that will take place during the first six weeks of the 2018–2019 school year, will be the use of the Cognitive Rigor Matrix developed by Hess (2009) to assess the level of student understanding of scientific content and concepts displayed as a result of argumentation. This investigation will clarify the role of argumentation in the depth of knowledge and understanding of my students, and provide more insight into how a focus on argumentation influences student learning. I will explore the impact of instructional and discourse factors on the depth of understanding demonstrated by students and the consistency across the lesson.

The performance assessments, lesson transcripts, teacher-research field notes, and PLC observations described in the first goal of this study will also be used to assess the level of student understanding across each phase of the qualitative case study. A Priori codes will be determined using the Cognitive Rigor Matrix by Hess (2009). Student and teacher statements, PLC observation notes, student artifacts and teacher-research field notes will be coded to identify relationships and patterns within various levels of student understanding across types of discourse, student experiences, and instructional practices.

The results of this study will be complied using content analysis. Any themes that emerge from data analysis will be described and reported. The findings will be used to refine teacher and student practices to further increase student empowerment and science achievement in my first grade classroom. I plan to continue the cycle of action research following this study.

Phase 2

The second phase of the action plan includes a goal for my PLC and other colleagues interested in expanding their practice as it relates to scientific inquiry-based instruction. I am committed to increasing teacher risk-taking, which includes that of my PLC and myself. The results of this study highlight the relationship between student understanding and teacher instructional practices that focus on student empowerment, not student compliance. Student empowerment involves a significant amount of teacher risk-taking. The inclination to avoid risks and disruption of the status quo diminished when I focused on scientific practices and the elements of the EQUIP rubric developed by Morton, Marshall, and White (2009). Phase 2 of this action plan involves strengthening this focus on practice and risk-taking for myself, as well as my colleagues.

The first part of this plan to increase a focus on practice, not content or negative student behavior, is to increase understanding of the EQUIP rubric and other lesson evaluation tools developed by Morton, Marshall, and White (2009). Each month during the 2018-2019 school year my PLC and I, along with any other colleagues interested in participating, will use our increased understanding of the EQUIP rubric to evaluate colleague instructional practices. Each colleague will choose a science lesson to record and share with the PLC to observe and rate. The observations will be shared and discussed. These evaluations will be used to determine monthly goals and collaborative planning based on the collective goal to improve the inquiry-based instructional practices of each colleague.

The second part of this plan will be to increase teacher efficacy in the scientific practices. During each unit planning session with my PLC we will identify two scientific practices from the *Framework* (National Research Council, 2012) to integrate with scientific content and concepts. The continuum of proficiency presented by the Next Generation Science Standards (2014) will be used to establish clear expectations of student proficiency in each scientific practice. At the end of each unit we will review student work to analyze student practice and determine future initiatives or interventions.

I will record observations, new understandings, and problems discussed during each PLC meeting that takes place during the 2018-2019 school year. These notes will be complied and analyzed by the PLC at the end of the year to further refine our teaching practice and determine the priority of future actions to better serve our students. Our reflections and decisions will also guide the direction of future classroom research. I will share any findings from this or any other research with fellow educators at my school and within my school district. I will also attempt to share them with colleagues beyond my district through educational publications or journals.

Suggestions for Future Research

The limitations of the study suggest areas for further research. As part of the action plan described previously, the next phase in the cyclical process of action research will involve a study solely focused on the impact of discourse factors, exploring the use of different conversation protocols on student proficiency in the practice of argumentation. The findings of this study suggest the need for further research in the area of constructive academic conversations and their impact on the depth of understanding of science concepts and content and the resulting science achievement, especially as it relates to early elementary students.

Another area for future research emerged from the limitations of this study. Student reflections were included in this study, but the impact of those reflections was not explored or measured. The presence of student reflection in my teacher-researcher field notes indicates that student reflection is a critical piece of improved student proficiency in scientific practices. Similar to discourse, reflection is an element of instructional practice that is often absent from state and national science curriculum units. Research in this area is necessary to measure its impact on science achievement.

A theme that was not considered previous to this study was academic empowerment. Behaviors of compliance shifted to empowerment as students interacted in a community of practice to construct, defend, and expand on ideas. Classroom practice would benefit from future research that explored the specific teacher and student behaviors that reflect educational empowerment, and the instructional strategies that encourage those behaviors. Research in the area of teacher empowerment and its relationship to teacher risk-taking and use of innovative student-centered practice will make an impact on educational policy and school culture.

Conclusion

This Dissertation in Practice (DP) explored the impact of a focus on student proficiency in generating a scientific argument from analyzed and interpreted data on inquiry-based practices. In Chapter One I presented the research question, related literature, and research design of this study. In Chapter Two, I provided an extensive review of related literature on inquiry and science-based practices and their impact on student learning. A description of the qualitative case study design employed in this study was found in Chapter Three. Chapter Four included a detailed account of the primary themes that emerged from qualitative content analysis of transcribed lessons, PLC lesson observations, and teacher-researcher field notes. Chapter Five summarized the significant points and implications of the study and described suggestions for future action. The cycle of action research will continue as the action plan described in this chapter is implemented in the next school year.

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Appendix A:

Parental Consent Form

Dear Parent/Guardian:

Fork Shoals School is an authorized International Baccaluareate Primary Years Program school. The first-grade teachers at Fork Shoals School are dedicated to providing inquiry-led instruction aligned with the International Baccaluareate Primary Years Program curriculum standards and guidelines. We are continuously collecting and reflecting upon data to better serve the first-grade students at Fork Shoals.

As a first-grade teacher at Fork Shoals and a doctoral candidate at the University of South Carolina, I am interested in how a workshop model similar to the reading and writing workshops currently used in your child's classroom will influence student inquiry. The first-grade teachers will use a similar workshop model during the upcoming unit on patterns in the sky. I plan to collect some limited data from the first-grade students to determine the impact of a workshop based on Barabara Stripling's (2003) inquiry cycle.

Your child's participation will involve a questionaire provided each week during the six-week unit on patterns of the sky. The questinaire will ask the students to reflect on the frequency of specific inquiry practices using a 4-point scale. It will also give students two open response questions to share what they discovered during that week. This weekly questionaire will give teachers data to inform their teaching practices. It will also give me (the teacher researcher) important data on the impact of the workshop model upon student inquiry.

Data collected will be kept confidential and all students will remain strictly anonymous and confidential. The results of this research may be published and included my (the teacher researcher) doctoral disertation at the University of South Carolina, however the school and indiviual identities will not be used. There is no penalty for not participating in this research study. Participants may withdraw from the study at any time without penalty. There are absolutely no physical, psychological, legal, or other risks in participating in this study.

The results of the study will be provided upon request.

If you have any questions concerning the study or your child's participation in this study please contact me at (864)355-5026 or wgrant@greenville.k12.sc.us.

Sincerely,

Whitnee Grant
First-grade Teacher - _______________ School
Doctoral Candidate – University of South Carolina

Parental Consent Return Slip

Study: Impact of Workshop Model on Inquiry-Based Instruction
Teacher Researcher: Whitnee Grant

Documentation of Permission:
I have read the study described above and I give permission for my child to participate in the study by completing an anonymous student questionnaire each week. I understand I can withdraw my child at any time. My signature indicates I allow the anonymous data collected from my child to be included in a doctoral dissertation or a published study.
Please return this form to your child's teacher by September 2017.

______________________	______________________	___________
Child Signature:	Print Name:	Date:
______________________	______________________	___________
Parent/Guardian Signature:	Print Name:	Date:

Relationship to Child (e.g. mother, father, guardian): ________________________________

______________________	______________________	___________
Signature of Person Obtaining Consent	Print Name:	Date:

Appendix B:

Research Proposal

Proposal Title: Action Research Study of the Impact of the Workshop Model on Inquiry-Based Instructional Practices

Project Start Date: February 26, 2018
Project End Date: March 30, 2018

Researcher Contact Information: Whitnee Grant
Fork Shoals School
wgrant@greenville.k12.sc.us
355-5026

Purpose of the Study

The purpose of this action research study is to examine structural elements that support practical teacher application of the inquiry-based approach. The ultimate objective is to establish effective tools and practices to improve student science achievement and increase teacher execution of student-centered inquiry-led learning in everyday classroom practice within a public school evaluated by content-driven standardized tests. The teacher-researcher intends to develop an Inquiry Workshop Model (IWM) within the previously developed concept-driven inquiry units to evaluate the effectiveness of a IWM in increasing everyday classroom practice of student-centered inquiry-based teaching for first-grade participants at Fork Shoals School.

This study will contribute to the educational advancement in Greenville County Schools. The current teacher-centered practices for teaching science standards at Fork Shoals

School do not reflect the student-centered practices valued by Greenville County School District. Fork Shoals is an authorized International Baccalaureate Primary Years Program. The recommendations of the International Baccalaureate Organization (2009) include a priority for inquiry-based instruction. This study will provide Greenville County School teachers valuable insight into tools and methods to support and increase inquiry-based instruction.

Procedures

Mills (2014) defines action research as teacher-led inquiry conducted to gain insight into teaching and learning within the environment in order to effect positive change and improve student outcomes. The goal of this case study is to investigate the impact of a Repeated Structure Workshop Model (RSWM) on inquiry-based instructional practices in an effort to "effect positive change" within the first-grade classrooms at Fork Shoals School (Mills, 2014, p.5). The teacher researcher will study her teaching practices and their affects on her students in order to improve the quality of her teaching, characterizing this case study as action research.

The primary participants of this action research study are the teacher researcher and the student participants that comprise her first-grade class at Fork Shoals School. A mixed-method design will be used to assess the impact of the Inquiry Workshop Model on the first-grade teacher's inquiry-driven practices when teaching patterns of the sun and moon. Quantitative and qualitative data will be collected from the teacher researcher and student participants prior to, during, and after the six-week study. Data collected will be analyzed to determine the impact of a IWM, as well as the possible next steps to further strengthen inquiry-based instructional practices for IB PYP teachers and students at Fork Shoals School.

The primary method to evaluate the impact of the IWM on daily inquiry-based instructional practices will be a weekly questionnaire. The weekly questionnaire will be comprised of two open-ended self-reflection questions and five Likert-type questions.

The teacher-researcher and student-participants will complete the questionnaire prior to using the IWM within the unit of inquiry into the patterns of objects in the sky, as well as at the end of each week during the unit and at the culmination of the unit. Questions will be formulated to encourage participants to self-reflect on personal interactions with inquiry-based instructional practices within the structure of the IWM.

The second method to measure the effectiveness of IWM on shifting teaching and learning practices will take place within focus groups through class discussions. The teacher researcher will record concerns, reflections, and realizations discussed in the focus groups as the participants share experiences interacting with the IWM. Meeting notes will provide qualitative data on the impact of implementing the IWM on inquiry-based practices, as well as on the varied interpretations and perspectives of the participants.

Mertler regards honesty as "absolutely essential when conducting research" (Mertler, 2014, p.112). The teacher researcher will be committed to honest communication with participants throughout the case study in order to create an authentic environment of inquiry. All participants will be honestly informed as to how, why, and what data will be collected. An informed consent form describing the nature of the study will be given to each teacher and student participant, giving students and parents full disclosure of the research study. The parental consent letter will include a guarantee of confidentiality and anonymity, information on the methods of data collections, and an offer for a summary of findings (Mertler, 2014).

Ethical Considerations

The teacher researcher will communicate honestly with the Greenville County School district and Fork Shoals School administration prior to initiating the action research study and throughout the completion of the study. A research proposal will be submitted to the Director of Research, Evaluation, and Accountability for Greenville County Schools in Fall 2017. The case study will comply with research guidelines established by Greenville County Schools Accountability and Quality Assurance as outlined in the research proposal (Greenville County School District, 2016). Fork Shoals School administration will be offered full disclosure of all elements of the case study, methodology, and analysis. Upon conclusion of the study a full report will be submitted to the Greenville County Director of Research, Evaluation, and Accountability as stated in the Greenville County Research Guidelines (Greenville County School District, 2016).

Collaboration and participation of teacher participants will be voluntary and teacher participants will be free to withdraw from the case study at any time. Specific data collected from teacher participants will allow teacher participants to remain anonymous and their responses to be kept confidential. The teacher researcher and teacher participants will allow student participants to remain anonymous when completing student surveys. Students without informed consent from a parent or guardian will participate in the inquiry-based instruction, but will not complete the student survey each week.

Conclusions

Any conclusions and results of this action research study will be fully disclosed with Greenville County School District. This action research study will be published as a dissertation for a doctoral candidate through University of South Carolina.

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Appendix C:

Lesson Plans and Performance Assessments

Lessons and Performance Assessments

Lessons and Performance Assessments within a Content Storyline Unit on the properties and uses of Natural Resources				
Phase	**Question**	**Potential Claims (Learning Outcomes)**	**Potential Evidence**	**Activity that provides opportunity to collect data necessary for evidence**
1 – Performance Assessment 1	What are natural resources?	Natural resources come from nature. People use natural resources	· All items come from nature · People use all of the items	The students will be given a collection of natural resources. The students are told that all the items are natural resources. The students are directed to generate two claims about what natural resources are based on the data provided.
2 – Lesson 1	What do living things have in common?	Living things use energy from the sun or food, reproduce, grow and change, and respond to the environment.	Patterns in data show that all living things reproduce, use energy from the sun, and grow and change	Students will collect data as a class for each item they believe to be living and the items they believe to be nonliving on a chart/table. The students will use the chart/table to find patterns and trends for all living things.

2 – Lesson 2	Are natural resources living or nonliving?	Some natural resources are living, like plants and animals. Some natural resources are nonliving, like rocks, sand, and soil. Some natural resources are dead, like cut flowers or sticks not in water or acorns. Some natural resources are living because they have the potential to be living like seeds.	· Plants and animals grow and change on their own. · Plants and animals need water and energy from food or the sun to grow and change. · Rocks, soil, and sand do not use energy from the sun/food to grow and change. · Seeds are living when they grow into a plant. · Sticks cannot grow once they are disconnected from the tree.	The students record data on natural resources to determine if they match the characteristics of a living or a nonliving object.
2 - Performance Assessment 2	What do seeds need to grow into a plant?	Seeds need water to sprout. Seeds need sunlight to continue to grow.	The seed placed in: · The sun with no water did not sprout · The sun with water sprouted and grew · The cabinet (no sun) with water did sprout but did not grow very much and was yellow. · The cabinet (no sun) w/o water didn't sprout.	Students will record changes in seeds placed in four different conditions: no sun & no water, no sun & water, sun & no water, sun & water.

3- Lesson 3-4	What are rocks?	Rocks are solid. Rocks are made f different aterials. Rocks are ifferent sizes. Rocks cover the arth.	Rock observations find: Some rocks have more shiny parts, shells, or layers than others. Some are big and some are small. Some rocks let out air bubbles in water. Rocks do not change shape depending on container they are in. Rocks are found in nature.	Students collect rocks on nature walk, observe rocks with hand lens, observe rocks in water, and read texts about rocks. After each activity data is recorded. Patterns in the data are discussed to determine what is common about all rocks.
3 – Performance Assessment 3	Are all rocks hard?	· Rocks have different levels of hardness.	Some rocks make dust or make a mark when scratched. Some rocks do not make dust or make a mark when scratched. A nail makes a silver mark when scratched on some rocks. A nail changes some rocks when scratched on the rock.	Students collect data using a variety of rocks: · Does the rock make a mark when scratched on black paper? · Does the rock make dust when scratched on black paper? · Does the rock change when scratched with a nail?

4 – Lesson 5	What is the best paper towel?	· ______ is the best paper towel	The best paper towel: · Absorbs water · Does not fall apart in use	Students test each brand of paper towel: • Towel absorbency by recording how many drops of water it can hold using a water dropper • Towel strength by finding how much weight it can hold on a wet spot by recording how many weights it can hold • Towel properties by observing towel with a magnifying glass.
4 – Lesson 6-7	Which soil is the best material for growing plants?	Loam is the best soil for plants because it holds water but it doesn't hold too much water.	· Sand does not hold water. · Clay holds too much water. · Loam holds water, but not too much water.	Students will test qualities of sand, silt, and clay to determine if they would help or hurt a growing plant. The data collected on each soil: How much water does the soil hold? Does the soil have minerals? Can roots grow?
4 – Performance Assessment 4	Which soil is the best for making bricks?	Clay makes the best bricks because it holds it shape and stays in that shape when it dries.	It is difficult for a sand brick to hold its shape if it is touched or moved. Loam does not hold its shape when wet. A clay brick holds its shape when wet, keeps its shape when touched, and stays in that shape as it dries.	Students add water to loam, sand, and clay to form a brick shape. Students collect data after each brick is formed. What happens when the brick is touched? Does the brick hold its shape? Does the brick stay in that shape as it dries?

<u>Performance Assessment 1:</u>

<u>Question:</u> What are natural resources?

<u>Framing the Question:</u> The students will be given a collection of items that are considered to be natural resources. The items will include a cotton plant, rocks, water, soil, a potted plant, and sticks.

<u>Collecting, recording, and interpreting data:</u> The students will observe each item and collect data on a recording sheet. On a recording sheet students will write a check in the box if the item is edible, moves, is found in nature, breathes, or is used by people or animals. Students will look for patterns in the data.

<u>Generating an argument</u>: Students will use data on a recording sheet to write a claim about natural resources based on the patterns observed in the data. Students then write the evidence from the data that supports their claim. The students will also be encouraged to write the reasoning to connects the evidence to the claim.

<u>Performance Assessment 2:</u>

<u>Question:</u> What do seeds need to grow into a plant?

<u>Framing the Question:</u> The students will reflect on discussions about whether a seed is living or nonliving. The students will predict and record what will happen to a seed when it is placed in four different conditions: no sun & no water, no sun & water, sun & no water, sun & water.

<u>Collecting, recording, and interpreting data:</u> The students will observe and record observations a recording sheet of each seed after one week, and again after two weeks. The students will compare predictions with final observations.

<u>Generating an argument:</u> Students will use data on a recording sheet to write a claim about what seeds need to change and grow into a plant based on the changes observed in the data. Students then write the evidence from the data that supports their claim. The students will also be encouraged to write the reasoning to connects the evidence to the claim.

<u>Performance Assessment 3:</u>

<u>Question:</u> Are all rocks hard?

<u>Framing the Question:</u> The students will reflect on discussions about the observed properties of rocks during previous lessons. The students will determine how we would know if all rocks are hard or if some rocks are hard and some are soft.

Collecting, recording, and interpreting data: The students will observe and record observations a recording sheet of how rocks react when scratched with a nail or scratched on black paper. The students will interpret patterns in the data.

Generating an argument: Students will use data to write a claim about the hardness of rocks. Students then write the evidence from the data that supports their claim. The students will also be encouraged to write the reasoning to connects the evidence to the claim.

Performance Assessment 4:

Question: Which material makes the best brick?

Framing the Question: The students will reflect on different ways people use natural resources. The students will determine what properties would a brick need to have to be useful.

Collecting, recording, and interpreting data: The students will add water to sand, loam, and clay and form a brick. The students will record data on a recording sheet for each brick that answers: What happens when the brick is touched? Does the brick hold its shape? What happens when the brick dries? The students compare data with properties discussed at the beginning of the lesson.

Generating an argument: Students will use data on the recording sheet to write a claim about the best material for bricks. Students then write the evidence from the data that supports their claim. The students will also be encouraged to write the reasoning to connects the evidence to the claim.

Lesson Plan 1

Assessing prior knowledge: What do living things have in common?

Framing the question: The teacher will frame the question by saying: Yesterday we looked at objects that are referred to as natural resources. How do we know if those objects are alive or not?

Making Predictions: The students will predict what is true for all living things. The teacher will model how an investigation will allow the students to test these claims and collect data.

Collecting, recording, and interpreting data: The students will collect data on characteristics of various living and nonliving objects based on ideas discussed. As students collect data, the teacher will model recording data on a class chart. Different colored post-it notes will be used to scaffold student interpretation of patterns in the data.

Constructing a scientific explanation: The students will use the patterns found in the data to answer the question: *What do living things have in common?*. The teacher will introduce the Claim-Evidence-Reasoning Framework. The teacher will create an anchor chart using examples from the claims students made about what living things have in common. The teacher will introduce sentence starters for claim and evidence: I claim all living things ____. The evidence that supports my claim is ______. The teacher will make thinking visible by recording student claims and evidence on chart.

Lesson Plan 2

Assessing prior knowledge: Are natural resources living or nonliving?

Framing the question: The teacher will frame the question by saying: Yesterday we looked at what all living things have in common. How can we use those characteristics to make a claim about whether natural resources are living or not?

Making Predictions: The students will review what is true for all living things. The students will predict if items found on the earth are living or not.

Collecting, recording, and interpreting data: The students will collect data on natural resources to determine if each natural resource matches the characteristic of a living object. The students use highlighters to show patterns in the data.

Constructing a scientific explanation: The students will use the patterns found in the data to answer the question: *Are natural resources living or nonliving?*. The teacher will review the Claim-Evidence-Reasoning Framework using the anchor chart. The teacher will introduce sentence starters for claim, evidence, and reasoning: I claim natural resources are ____. The evidence that supports my claim is ______. I think my evidence matches my claim because all living things ______. The teacher will make thinking visible by recording student claim, evidence, and reasoning on chart.

Lesson Plan 3-4

Assessing prior knowledge: What are rocks?

Framing the question: The teacher will frame the question by saying: We discovered rocks are an item we can find in nature. What are rocks? How do you know which natural resource is a rock and what is soil?

Making Predictions: The teacher will introduce the term *properties*. The students will predict what the properties of a rock could be.

Collecting, recording, and interpreting data: Over the course of a few days the students will collect rocks on a nature walk, observe rocks with a hand lens, observe rocks in water, and read texts about rocks. After each activity the students will record what they learned about rocks. Then the students will find properties that are true for all rocks by looking at repeating patterns in the data.

Constructing a scientific explanation: The students will use the patterns found in the data to answer the question: *What are rocks?*. The teacher will review the Claim-Evidence-Reasoning Framework using the anchor chart. The teacher will introduce sentence starters for claim, evidence, and reasoning: I claim all rocks are ____. The evidence that supports my claim is ______. I think my evidence matches my claim because properties ______. The students will make thinking visible by working with a partner. Partners share claim and evidence with a partner, the partner restates the student's claim and adds an additional piece of evidence. Then the partners state the reasoning that connects the claim to the evidence. The teacher makes thinking visible by recording partner claims, evidence, and reasoning on a chart.

Following the lesson the teacher will model how scientists critique a scientific argument by introducing norms for agree or disagree. The students will review the chart of partner claims, evidence, and reasoning and practice using the norms for agree and disagree to critique each argument. Critiques and related discussion will lead to a final claim with more than one piece of evidence in logical reasoning.

Lesson Plan 5

Assessing prior knowledge: What is the best paper towel?

Framing the question: The teacher will frame the question by saying: We have learned that trees are a natural resource because they are used to make paper for people to use. How do we know what kind of paper towels are the

Making Predictions: The students will predict what makes a paper towel most useful. If students are having trouble making statements about what characteristics paper towels should have to be useful the teacher will show students a few paper towel commercials.

Collecting, recording, and interpreting data: The students will collect data on various brands of paper towels. The students will test and record towel absorbency by dropping water on each brand and recording how many drops it can absorb, towel strength by adding weights to towels and recording how many weights each towel can hold, and towel properties by observing and recording the visual properties of each towel. The students will compare the results of each towel across the three categories.

Constructing a scientific explanation: The students will use the comparisons in the data to make a claim about the best paper towel. The teacher will review the Claim-Evidence-Reasoning Framework using the anchor chart. The students will use the Claim-Evidence-Reasoning Framework to write an argument for the best towel. The students will share arguments. Student volunteers will make thinking visible by placing their written claim, evidence, and reasoning under the document camera. Students highlight the part of the student writing that is the claim, the evidence, and the reasoning.

Lesson Plan 6-7

Assessing prior knowledge: What soil is the best for growing plants?

Framing the question: The teacher will frame the question by saying: We have learned that soil is a natural resource because it is used to grow for people to eat and use to make things. We've learned there are different types of soil. How do we know what kind of soil is the best for growing plants?

Making Predictions: The students will review what plants need to grow. The students will predict what kind of soil would support those needs.

Collecting, recording, and interpreting data: Over the course of a few days students test soil for properties that will help plants have the sun, water, nutrients, and air they need to grow. The students will collect data on the minerals found in sand, loam, and clay. The students will collect data on how much water sand, loam, and clay can hold. The students will collect data on the air that is in sand, loam, and clay. The students use highlighters to find patterns that correspond to the conditions plants need to grow for each type of soil.

Constructing a scientific explanation: The students will use the Claim-Evidence-Reasoning Framework anchor chart to write an argument for the best type of soil for growing plants. The teacher will support students who still need scaffolding by asking questions that elicit student thinking or by providing sentence starters.
Students share arguments with a partner. Partners will use the 'agree or disagree' norms to critique the scientific argument provided. Partners will revise arguments based on discussions. Partners share with the class as the teacher records to make thinking visible. A claim with multiple pieces of evidence and reasoning to support the claim is determined and agreed upon based on discussions.

Appendix D:

Performance Assessment Rubric

Performance Assessment Rubric Rubric adapted from McNeill and Krajcik (2012) & SC Science and Engineering Practices (2014)					
	0 Does not meet	**1 Developing**	**2 Approaching**	**3 Proficient**	**4 Exemplary**
Claim	Does not make a claim.	Makes an inaccurate claim	Makes an accurate but vague claim.	Makes an accurate claim.	Makes an accurate and complete claim.
Evidence	Does not provide evidence.	Provides vague evidence or evidence that is not provided by the data.	Provides 1 piece of evidence from the data that logically supports the claim	Provides 2 pieces of evidence from the data that logically supports the claim	Provides more than two pieces of evidence from the data that logically supports the claim
Interpret Data	Records but does not interpret data.	Organizes or describes the data collected but does not recognize patterns or relationships.	Describes patterns or relationships but interpretations are not logical or directly related to the data.	Student interprets data to describe logical patterns, relationships, and/or predictions that support arguments or claims.	Student interprets data to construct meaning and describe logical patterns, relationships, and/or predictions. Interpretations support arguments or claims.
Reason	Does not provide reasoning			Connects the evidence to the claim with an explanation.	Connects the evidence to the claim with an explanation by using a scientific principle.